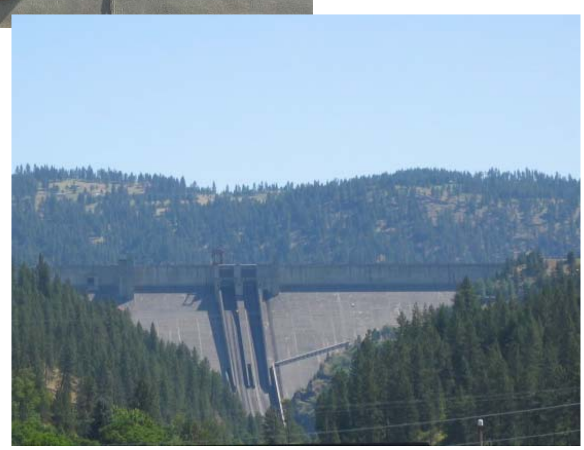
ENGINEERING SERVICES FOR WATER TREATMENT FEASIBILITY STUDY AND CONCEPTUAL PLANNING DOCUMENTS

PHASE II FEASIBILITY STUDY

DWORSHAK NATIONAL FISH HATCHERY
AHSAHKA, ID



MARCH 2008

PREPARED BY:
THE CONSERVATION FUND
FRESHWATER INSTITUTE

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EXECUTIVE SUMMARY

Dworshak NFH raises 2.0–2.2 million steelhead smolts annually to release into the Clearwater River as part of the U.S. Army Corps of Engineers Dworshak Dam mitigation program. The hatchery also participates in the Lower Snake River Compensation Plan, raising 1.0–1.04 million Chinook salmon smolts for the North Fork River each year. Returning broodstock for each program are collected at the facility's fish ladder and are held and spawned onsite. Additionally, 280,000 Coho salmon smolts are raised as part of a cooperative program with the Nez Perce Tribe and 15,000 rainbow trout are raised for outreach events. This analysis and report evaluates the water and wastewater infrastructure at Dworshak NFH, and makes the following four recommendations for hatchery improvement.

1. **BEST MANAGEMENT PRACTICES TO IMPROVE REUSE SYSTEM WATER QUALITY AND MEET DISCHARGE PERMIT LIMITATIONS**
   Dworshak NFH currently discharges the majority of hatchery effluent directly to either the North Fork of the Clearwater River or the Clearwater River with minimal or no effluent treatment. Removal of waste solids is particularly problematic when Burrows ponds are operated in reuse configuration, which contributes to poor fish health. The best management practice of microscreen filtration of hatchery effluent is recommended to improve the hatchery effluent quality and to provide efficient removal of waste solids during hatchery operations.

2. **BURROWS POND RENOVATION FOR IMPROVED OPERATION AND FISH HEALTH**
   Juvenile steelhead are raised in 84 outdoor Burrows ponds for 10–11 months each year at Dworshak NFH. These ponds have poor operational hydrodynamics, resulting in significant dead zones that allow for the accumulation of waste solids within ponds. Waste solids break down into smaller particles and leach nutrients as they accumulate, degrading water quality and negatively impacting fish health. Burrows ponds should be renovated to improve the operational hydrodynamics and solids removal capability. Renovations will transform a rectangular Burrows pond into three circular tanks with bottom center drains by changing the way water is supplied to and removed from the pond. It is recommended that one or two ponds be renovated and pilot-tested prior to renovating all of the ponds.

3. **UTILIZATION OF A HEAT EXCHANGER SYSTEM TO ACHIEVE A NATURAL REARING WATER TEMPERATURE REGIME AND ENERGY SAVINGS**
   Water from the North Fork of the Clearwater River serves as the primary water supply for Dworshak NFH; all outdoor fish culture areas receive river water. The North Fork River near the hatchery does not follow a natural surface water temperature profile because it is influenced by the upstream Dworshak Dam; river water temperatures are significantly colder. Steelhead raised on station do not experience enough growth during the summer and early fall months to reach target stocking sizes due to colder North Fork water suppressing growth. As a result, steelhead culture water is heated with boilers during the winter months to increase growth and Burrows ponds reuse systems are operated. Operation of boilers and Burrows ponds in reuse could be abandoned, and a heat exchanger system could be implemented utilizing warmer water from the Clearwater River to temper North Fork water, resulting in a more natural temperature profile for fish and 12 million kWh energy savings per year.

4. **IMPROVED DISSOLVED GAS CONDITIONING OF THE NURSERY ROOM WATER SUPPLY**
   Water from the Dworshak Reservoir is always used to supply the 128 nursery tanks. Reservoir water is super-saturated with dissolved nitrogen, which further increases when it is heated from January through May. Individual packed columns installed above each nursery tank are used to treat the water supply; however, recent dissolved gas testing indicates both ambient and heated reservoir water have higher than optimal levels of dissolved nitrogen after treatment with these packed columns. Dissolved nitrogen saturation over 102–104% is a chronic stress to juvenile fish in the nursery and should be addressed with a new centralized dissolved gas conditioning system that would lower dissolved nitrogen levels below 100% of saturation.

REVIEW OF EXISTING CONDITIONS

Hatchery Background Information

Contact Information

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Dworshak National Fish Hatchery
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Website: http://www.fws.gov/dworshak

Staff and Organization

Complex Manager	Larry Peltz
SRBA Hatchery Coordinator (NPT)	Ed Larson
Hatchery Manager	Vacant
Supervisory Fish Biologist	Bob Semple
Fish Biologist	Mike Bisbee
Fish Biologist	Mark Bright
Fish Biologist	Thomas Trock
Fish Biologist	Jill Olson
Animal Caretaker Leader	John Vargas
Animal Caretaker	Rick Allain
Animal Caretaker	Wayne Hamilton
Animal Caretaker	Rob Kellar
Animal Caretaker	Ben Wright
Animal Caretaker (NPT)	Lou Ann Laswell
Animal Caretaker	Vacant
Maintenance Mechanic Supervisor	Hubert Sims
Maintenance Worker	Rick King
Maintenance Worker	Dave Trainor
Maintenance Mechanic Helper	Krista Hostetler
Maintenance Mechanic Helper	Terry Weeks
Electronics Mechanic	Ben Greene
Laborer	Gerald Stretsbery
Administrative Officer	Joan Sperber
Purchasing Agent	Penny Hasenoehrl
Information Supervisor	Susan Sawyer
Information Officer	Megan Wandag

Location

Dworshak NFH is located in Clearwater County at 46°30′8″N and 116°19′24″W approximately 1.5 miles downstream of the Dworshak Dam. The hatchery is located off of State Highway 7 just outside the town of Orofino at an approximate elevation of 1,030 feet. Total average annual rainfall is 25 inches and total average snowfall is approximately 16 inches.

Figure 1. Aerial photograph of Dworshak NFH.

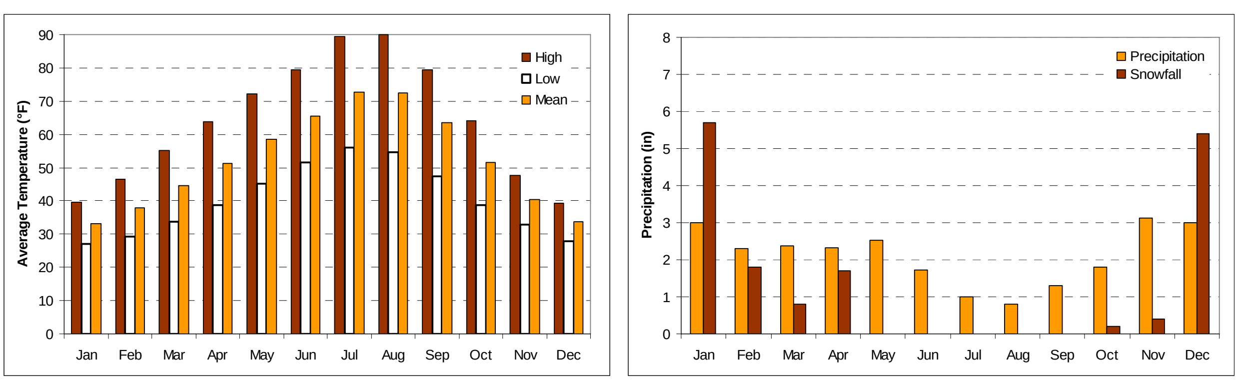


Figure 2. Mean temperature and mean precipitation for Dworshak NFH.

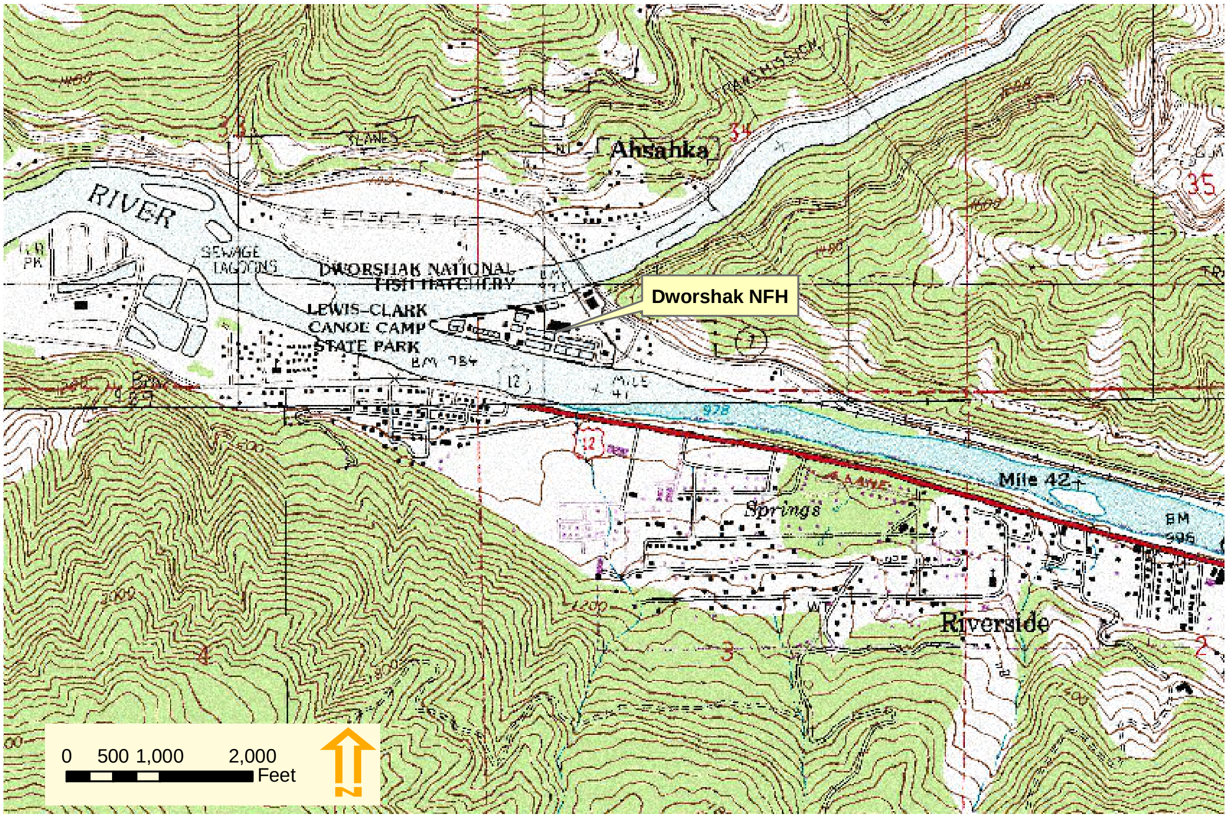


Figure 3. USGS topographic map of the area surrounding Dworshak NFH.

Facility Overview

Dworshak National Fish Hatchery (NFH) is located approximately 1.5 miles downstream of the Dworshak Dam on the peninsula between the North Fork of the Clearwater River and the Clearwater River. The hatchery is jointly operated by the U.S. Fish and Wildlife Service (USFWS) and Nez Perce Tribe, but is owned by the U.S. Army Corps of Engineers (USACE). The majority of operating expenses are also provided by the USACE. Congress authorized the construction of the Dworshak Dam for flood control and power generating purposes in 1962 and simultaneously approved the construction of Dworshak NFH. At 717 feet tall, the Dworshak Dam is the third tallest dam in the U.S. and too tall to accommodate fish passage; the hatchery was approved to mitigate the dam's impacts on migrational fish in the North Fork of the Clearwater River.

Dworshak NFH was designed and constructed by the USACE in two main phases. The first phase of construction was completed and hatchery operations began with steelhead production in 1969–1970. A second phase of construction was completed during 1972–1977, which added more fish production areas and the equipment for water reuse Systems II and III. The second mechanical building was also added during the second phase of construction, increasing the capacity for heating water and manipulating fish growth at the facility. Multiple renovations and modifications have occurred at the facility since its construction. The last major construction project at the hatchery took place in the early 1980s when the nursery building and raceways were constructed.

Dworshak NFH continues to fulfill its original purpose raising steelhead smolts for stocking into the Clearwater River Basin. The goal for the facility is to raise and release 2.0–2.2 million steelhead smolts into the Clearwater River each year in an effort to have 20,000 adult steelhead returning yearly to the mouth of the Clearwater River. To date, the return goal of 20,000 adults has only been met a few years. Adult steelhead broodstock are captured as they migrate up the facility's fish ladder, which is situated on the North Fork of the Clearwater River. Broodstock are kept in the holding ponds above the ladder until they are later spawned onsite. Steelhead eggs are incubated and early stages are reared in the incubation and nursery rooms using heated reservoir water. Each spring, young steelhead are stocked from the nursery into the outdoor Burrows ponds where they are raised for approximately one year and released the next spring when they are 180–200 mm in size.

In 1982, Dworshak NFH began a program to raise spring Chinook salmon as a Lower Snake River Compensation Plan (LSRCP) partner. The LSRCP was passed in 1976 to mitigate the impact of four dams on the Lower Snake River: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams. Dworshak NFH is currently one of ten hatcheries that participate in the plan. Dworshak NFH raises and releases 1.0–1.04 million Chinook smolts each spring in an effort to meet its goal of returning approximately 9,000 adults to the Lower Granite Dam each year, but has yet to meet its goal for returning adults.

In addition to the steelhead and Chinook salmon programs at Dworshak NFH, a small number of rainbow trout are raised at the facility to provide recreational fishing opportunities in surrounding areas. Fish culture rearing space and expertise are also provided for the Nez Perce Tribe to raise a small number of Coho salmon on station under the Snake River Basin Adjudication (SBRA) Agreement.

Facility Mission

Since its inception, the primary goal of Dworshak NFH has been to return 20,000 steelhead adults yearly to the mouth of the Clearwater River. To meet this goal, the hatchery currently raises and releases 2–2.2 million steelhead smolts. The hatchery also participates in the LSRCP, raising approximately 1–1.04 million spring Chinook salmon smolts that are stocked into the Clearwater River each year. As part of the SRBA Agreement, 280,000 Coho salmon smolts are produced at the facility under joint management between the USFWS and the Nez Perce Tribe.

Surrounding Land Use and Watershed Issues

Dworshak NFH lies within the Clearwater Watershed (USGS Cataloging Unit 17060306). The watershed area is heavily forested, and consists of areas that are owned and managed by the U.S. Forest Service and various private landowners. The Clearwater Watershed is also a popular big game hunting area for elk and deer.

Key Watershed Issues

Land Use

The land use summary for the portion of the Clearwater Watershed that feeds the Dworshak Reservoir upstream of the hatchery is illustrated in Figure 4. This watershed area consists of 734,950 acres. The water surface area of the reservoir changes depending on the water level elevation in the reservoir, but is 19,800 acres at its full pool elevation. Approximately 30,000 acres of land surrounding the reservoir is managed by the USACE for public recreation, wildlife habitat and mitigation, and log-handling facilities. Approximately 86% of the land area in Figure 4 is forested and a portion of that area is managed for logging. Development and urban land is negligible, accounting for less than 0.1% of the land area. Approximately 6% of the watershed area is barren, 3% is grassland, and 2% is shrubland.

Agriculture

The Idaho Fish and Game Department's (IDFG) Clearwater Hatchery is located across from Dworshak NFH on the southern bank of the North Fork of the Clearwater River. The Clearwater Hatchery was constructed in the late 1980s as part of the LSRCP. The hatchery is operated by the IDFG and raises 2.3 million spring Chinook salmon and 800,000 steelhead smolts in two-pass, flow-through raceways. Approximately 775,000 pounds of feed are fed at the station each year. Effluent from the Clearwater Hatchery is treated in settling basins and discharged to the North Fork approximately 100 feet downstream of the current Dworshak NFH settling pond discharge at the tip of the peninsula (outlet 005). The water supply for the Clearwater Hatchery comes solely from the Dworshak Reservoir.

Industry and Development

A portion of the land upstream of the hatchery consists of forests that are managed for logging activities. No major commercial development within the watershed area is anticipated.

Hatchery Watershed Impact

Approximately 420,000 pounds of fish are produced at Dworshak NFH on a yearly basis, fed a total of 465,000 pounds of feed. The hatchery utilizes a substantial amount of water and employs minimal effluent treatment. Plans for upgrading and adding effluent treatment processes are currently under development.

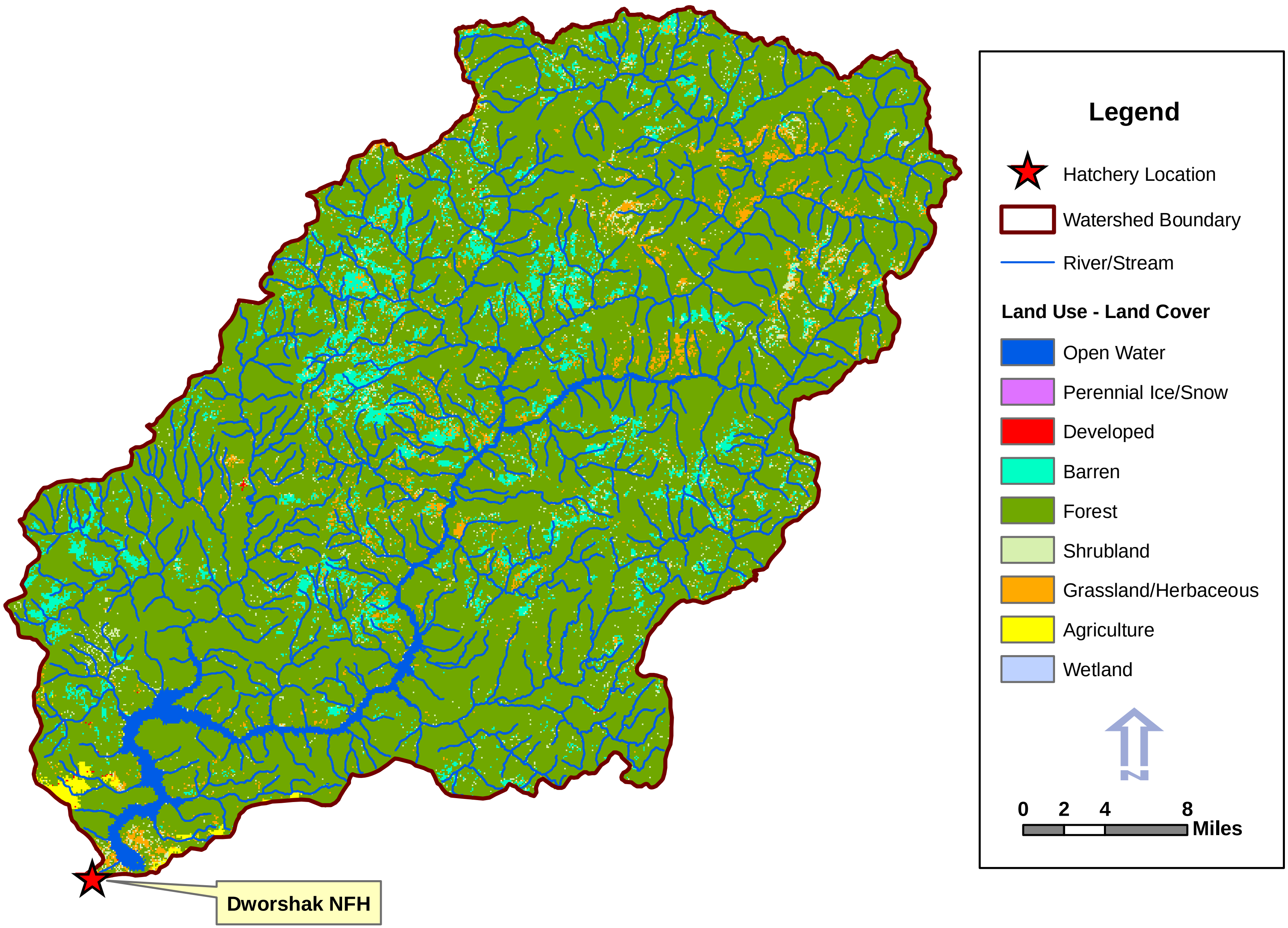


Figure 4. Land use for the watershed area surrounding the Dworshak Reservoir.

Water Supply

Source

Dwořshak NFH utilizes two water supply sources for fish culture activities: water directly from the Dworshak Reservoir above the dam or river water that is pumped from the North Fork of the Clearwater River at a location approximately 1.5 miles downstream of the dam. Water from the North Fork of the Clearwater River is the primary water source for Dworshak NFH.

Reservoir Water

Two intake lines were installed through the Dworshak Dam and extended into the reservoir during the construction of the IDFG's Clearwater Hatchery in 1986–1991. The dam is 717 feet tall and forms a 53-mile long reservoir that has a storage capacity of approximately 3,453,000 acre-feet at its operational water level elevation of 1,600 feet. Two reservoir intakes, one at a deep elevation and one at a shallow elevation, were installed to provide water to the Clearwater Hatchery, which is located across from Dworshak NFH on the other side of the North Fork. The deep reservoir intake has an 18-inch diameter supply line to Clearwater Hatchery that continues to Dworshak NFH. The deep intake is located in the reservoir at an elevation approximately 245 feet below the top of the dam. The shallower reservoir intake serves as the primary water supply intake for the Clearwater Hatchery. The primary intake is attached to a floating platform and can be adjusted from a depth of 5 feet below the water surface to 50 feet below the surface to obtain water of different temperatures. The primary intake has a 48-inch diameter supply line to the Clearwater Hatchery, where it is then reduced to a 24-inch diameter line that continues to Dworshak NFH. Operation of the reservoir intakes is controlled by personnel from Clearwater Hatchery; deep and shallow intakes can be operated separately or simultaneously.

Reservoir water is typically used for incubation and early rearing at Dworshak NFH. Both of the reservoir lines meet at a valve vault near the main aeration tower where they are combined into one 30-inch diameter line. This 30-inch diameter reservoir line goes to Mechanical Building 1, directly to the nursery tank building, or to Mechanical Building 2. Reservoir water can also be directed to the left side of the main aeration tower sump through a 24-inch diameter supply line, but such operation is atypical.

River Water

An overview of the hatchery's river water supply intake and treatment processes is provided in Figure 5. The river intake structure and main pump house is situated on the bank of the North Fork approximately 1.5 miles downstream of the Dworshak Dam. The river intake has a 48-foot wide, bar-type trash rack to remove large debris; trash rack bars are spaced three inches apart. The water level in the river changes seasonally as controlled by the dam, submerging the trash rack approximately 8 to 16 feet under normal operation. The trash rack has a mechanical rake that is turned on/off manually as needed, which is typically once a week. The gear motor for the rake was replaced recently and the system is reported to work well. Hatchery staff indicate no ice accumulation problems at the intake. A section of floating logs located in the river serve as an initial trash diverter upstream of the bar rack and intake.

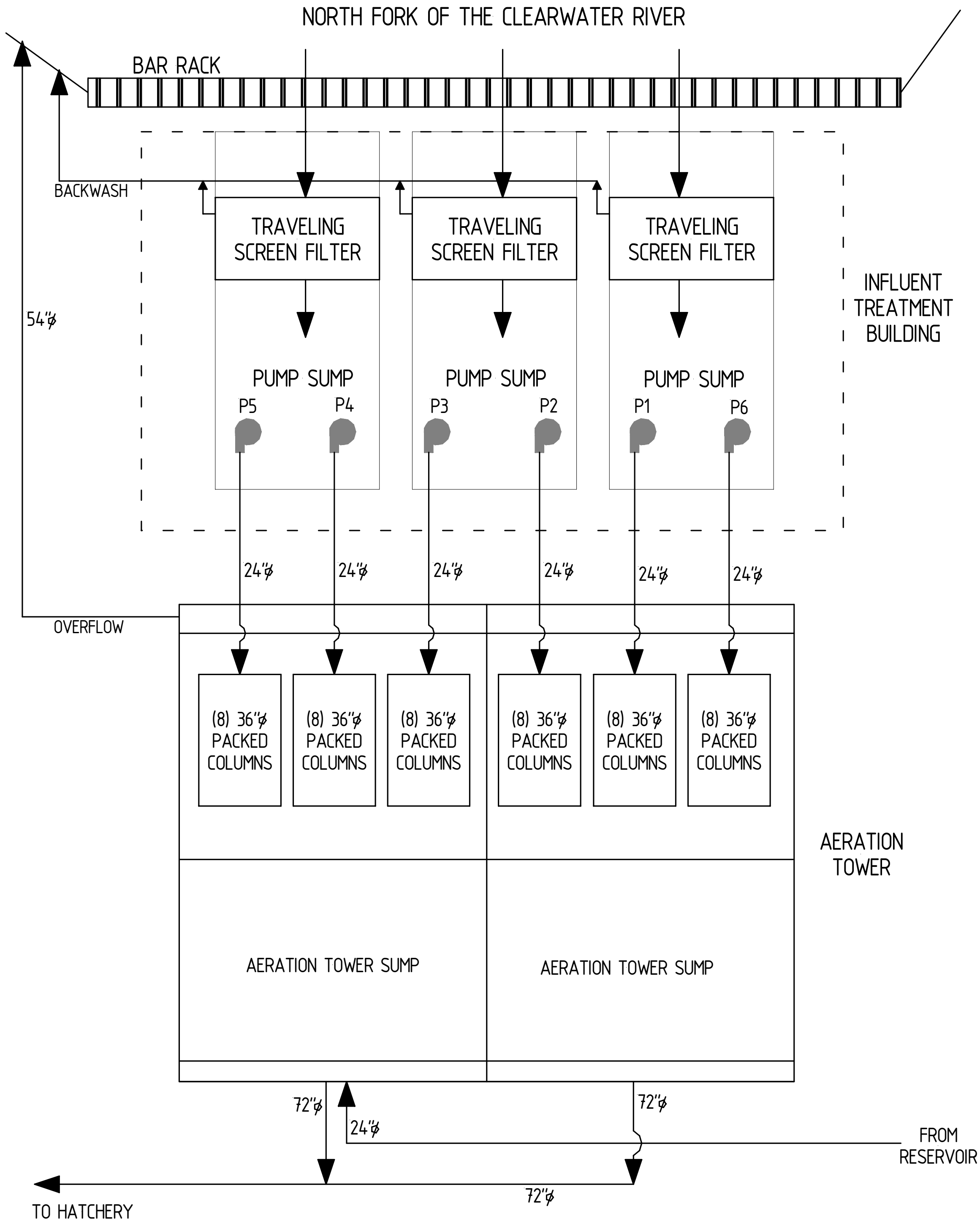


Figure 5. Dworshak NFH water supply process flow diagram.

The lower level of the main pump house is divided into three chambers, each with an interior width of approximately 14 feet. River water enters the pump house through the trash rack into one of the three chambers, where it flows through a traveling screen filter and then into a pump sump area (Figures 6 and 7). Stop logs can be inserted at the front of each chamber to block the flow of water into the area if required for maintenance purposes. The traveling screens, manufactured by the Link Belt Traveling Water Screen Company, are original to the hatchery, although they were reconstructed approximately 15 years ago. The traveling screen filters are ten feet wide and have stainless steel mesh media with 3/8-inch square openings to exclude debris. Each unit has an automatic backwash system that can be controlled by the pressure differential change measured across the screen. Backwash cycles are currently setup on a timer to operate six times per day for 15-minute durations. As each unit backwashes, the screens rotate and backwash water is discharged to the river through a channel underneath the pump house main floor. The outside portion of this backwash channel has a small bar rack that must be cleaned manually each day. The backwash water supply for the traveling screen filters is provided by the high pressure water system in the fire maintenance building located adjacent to the aeration tower.

River water is supplied to the pumps in the fire maintenance building by gravity from the aeration tower basin. The high pressure water system consists of two 15-HP pumps, one 40-HP pump, and a high pressure water storage tank (WellXTrol model 404 C) with a 68-gallon total volume. The pumps generate a pressure of 120 psi and have high efficiency motors. The pressure pump system is being upgraded to a variable frequency drive (VFD) control on-demand system. Current operation is continuous even when there is no demand for backwash water; water recirculates within the system when there is no demand. In addition to supplying the backwash water for the traveling screen filters in the influent treatment building, the system in the fire maintenance building also supplies water for the hatchery's lawn sprinkler system, fire suppression system, and cooling water to the refrigeration compressors in the feed building.

Each of the three main pump house chambers has two vertical turbine pumps after the traveling screen filters (Figures 6 and 7). Five pumps are original to the facility and the sixth pump was added in 1985. The original pump motors were 200 HP, but they were upgraded to 250 HP in 1994 when packed columns were added to the main aeration tower, increasing the total dynamic head against the pumps. Current pumps are capable of pumping 15,000 gpm against 55 feet of total dynamic head. Pump orientation is presented in the process flow diagram in Figure 5 and details are provided in the Table 4 pump schedule. The river surface water elevation varies from a minimum of 968 feet to a maximum of 980 feet, subsequently influencing the water level in the pump house. The bottom elevation of the pump house is 960 feet, and pump P5 sometimes experiences cavitation problems based on water level fluctuations. Each sump chamber has a low water level float switch with alarms in the main pump house and notification provided via the central hatchery alarm. Pump motors have to be manually started and staged to prevent operational problems. The motors do not have VFDs, but do have soft-start motors that allow a steady increase of power to each pump motor upon startup. Each pump motor has thermal overload alarm protection and an over-voltage alarm.

Figure 6. Traveling screen filters in the main pump house.

Figure 7. Vertical turbine pumps in the main pump house.

A diesel-powered, 625-kVA generator with automatic transfer switch is located in the main pump house. The generator only has the capacity to operate two of the facility's six main vertical turbine pumps during emergency power situations. The generator is exercised monthly and does not have any current operational problems. Approximately 45 gallons of fuel per hour is consumed during operation when the generator is fully loaded; a 1,000-gallon fuel storage tank located between the main pump house and aeration tower. The power plant substation for the hatchery is located directly across from the hatchery's river intake structure; however power failure events occur about 2–5 times each year. Outages are reportedly short in duration and the hatchery has the ability to operate at partial capacity with two main pumps; problems would be experienced if outages were longer.

Quantity

Dworshak NFH is not regulated on the amount of water that it is allowed to use from the river; however the six pumps at the river intake have a combined maximum pumping capacity of 90,000 gpm. The facility is limited in the amount of water that it can use from the reservoir. Clearwater Hatchery has rights to the first water use and also controls the depth of the shallow reservoir intake. Clearwater Hatchery typically uses 4,040 gpm from the deep intake and 34,420 gpm from the floating intake; leaving approximately 6,500 gpm for fish culture at Dworshak NFH. The amount of water required at Dworshak NFH varies throughout the year, and flowrates are not consistently measured on station. Estimates of the average monthly flowrates utilized from both water sources are summarized in Table 1.

	River Water (gpm)	Reservoir Water (gpm)	Total Water (gpm)
January[1]	50,400	3,135	53,535
February[1]	50,400	3,775	54,175
March[1]	50,400	5,725	56,125
April	68,400	5,285	73,685
May	24,000	5,210	29,210
June	27,600	5,170	32,770
July	53,400	5,170	58,570
August	68,400	5,390	73,790
September	77,400	270	77,670
October	77,400	200	77,600
November	77,400	75	77,475
December[1]	47,400	3,075	50,475

[1]Burrows ponds Systems I and II operated in reuse with 10% makeup water input.

Table 1. Average monthly water use at Dworshak NFH.

Quality

The ambient temperatures of river and reservoir water vary throughout the year. Water temperatures at the shallow intake can reach as high as 80°F during the summer, but the intake depth is adjusted deeper to maintain a temperature of 50–58°F during the summer and fall; the Clearwater Hatchery targets a temperature of 56°F most of the year. Water at the deep intake has a more consistent temperature, varying from 38°F to 45°F. Both hatchery water supplies are super-saturated with dissolved nitrogen. Dissolved gas measurements were collected by hatchery staff at various locations throughout the hatchery in November, 2007. Measurements were recorded at 15-minute intervals for 2–3 days at each location and averages of the results are summarized by location in Table 2.

Water Source	Temp. (°F)	TDGP (%)	N_2 Sat. (%)	O_2 Sat. (%)	DO (ppm)
Raw River Water[1]	48.5	104	106	94	10.7
Aerated River Water[2]	47	101	101	99	11.4
Aerated Reservoir Water[3]	41.6	100	103	87	11
Heated Aerated Reservoir Water[4]	54.3	101	104	89	9.3
Heated Reservoir Water[5]	54.6	113	113	112	11.6

[1]Raw river water measured in the middle chamber of the main pump house sump.
[2]River water post aeration tower packed columns as measured in the main aeration tower sump.
[3]Ambient reservoir water post nursery tank packed column as measured in a nursery tank with no fish.
[4]Heated reservoir water post nursery tank packed column as measured in a nursery tank with no fish.
[5]Heated reservoir water as measured in a nursery tank with no fish (no packed column treatment).

Table 2. Dissolved gas measurements collected by hatchery staff in November 2007 (reservoir water was being used from the shallow intake).

Influent water quality is not routinely monitored at Dworshak NFH; however samples are collected and analyzed by an outside laboratory as needed. Water quality sampling for the North Fork of the Clearwater River and the Dworshak Reservoir deep intake were completed in July 2007. A grab sample of river water was collected prior to treatment with packed columns at the aeration tower, and a grab sample of the reservoir water was collected at Dworshak NFH prior to heating or dissolved gas conditioning. Results from water quality testing are summarized in Table 3. Both water sources are very soft, have low alkalinity, and relatively low pH. The concentration of zinc is slightly higher in both sources than recommended for fish culture, but results indicate low concentrations of other metals.

Parameter	**River Water**	**Reservoir Water (Deep Intake)**	**Fish Culture Standards**[1]
Alkalinity (as $CaCO_3$)	<20	<20	10–400
Hardness (as $CaCO_3$)	12	11	10–400
pH	6.8	6.4	6.5–8.0 SU
Total Dissolved Solids	<20	<20	<400
Turbidity	0.6 TU	0.6 TU	--
Ammonia (NH_3)	<0.25	<0.25	<0.02
Nitrate (NO_3-N)	<0.5	<0.5	0–3.0
Nitrite (NO_2-N)	<0.5	<0.5	< 0.1 in soft water
Aluminum (Al)	<0.1	<0.1	<0.01
Arsenic (As)	<0.005	<0.005	<0.05
Barium (Ba)	<0.30	<0.30	<5
Calcium (Ca)	3.5	3.3	4–160
Cadmium (Cd)	<0.002	<0.002	<0.0005[2]
Chloride (Cl^-)	<5	<5	<0.003
Chromium (Cr)	<0.01	<0.01	0.03
Copper (Cu)	<0.004	<0.004	<0.006[2]
Iron (Fe)	0.035	0.032	<0.1
Lead (Pb)	<0.002	<0.002	<0.02
Magnesium (Mg)	0.81	0.71	<15
Manganese (Mn)	<0.004	<0.004	<0.01
Mercury (Hg)	<0.001	<0.001	<0.2
Nickel (Ni)	<0.02	<0.02	<0.1
Selenium (Se)	<0.02	<0.02	<0.01
Silver (Ag)	<0.002	<0.002	<0.003
Sodium (Na)	2	1	75
Sulfate (SO_4)	<5	<5	<50
Zinc (Zn)	0.008	0.015	<0.005
Trihalomethanes	ND	ND	--

[1]Source: Wedemeyer, 1997; U.S. EPA, 1979–80, Piper et al., 1982 [2]For alkalinity < 100 mg/L

Table 3. Water quality testing results from July 2007 sampling (ppm except where noted).

Influent Treatment Processes

Aeration Tower

Initial dissolved gas conditioning of river water is accomplished using packed columns at the hatchery's main aeration tower, which is located next to the main pump house. The packed columns (Figure 8) are located on top of a two-chambered, concrete head tower structure where treated water is stored and subsequently supplied to the hatchery. The sump portion provides approximately 334,000 gallons of storage capacity. The aeration tower has a non-adjustable overflow weir with a 54-inch diameter line that drains to the river at an outlet just downstream of the river intake structure. The top of the overflow weir is at an elevation of 1,007 feet providing an operational water level with approximately 12 feet of pressure head to the System I and II Burrows ponds when the aeration tower sump overflows. Although the aeration tower does have a low water level alarm, flows to or from the aeration tower are not regularly measured or monitored. Reservoir water can be added to the west side of the aeration tower sump, but cannot be treated with the packed columns.

Figure 8. Packed columns at the aeration tower.

River water is pumped to 48 packed columns on top of the aeration tower. There are no valves on any of the influent pumped lines to the aeration tower. Flows are adjusted by turning the main pumps in the influent treatment building on or off. Each pump has a 24-inch diameter manifold that supplies water to a bank of eight packed columns. Packed columns are all 4 feet tall, 36 inches in diameter, and filled with 3.5-inch diameter pall ring packing. Assuming the flowrate from one pump is divided equally among the eight packed columns fed through one pump manifold, the hydraulic loading rate for the packed columns is 265 gpm/ft^2 at the maximum pumping rate of 15,000 gpm. This hydraulic loading rate is well above the recommended hydraulic loading rate of 40–100 gpm/ft^2 for packed columns (Colt and Bouck, 1984). Operational efficiency of the packed columns is also reduced because water is not evenly distributed over the entire column surface area. November 2007 water testing indicates that the packed columns at the aeration tower increase dissolved oxygen content from 94% to 99% of saturation and decrease dissolved nitrogen super-saturation from 106% to 101% (Table 2).

Each side of the aeration tower sump has a non-adjustable, concrete outlet weir with a 72-inch diameter outlet located on the other side of the weir. The top elevation of the outlet weir on the east side of the aeration sump is 1001 feet, while the top elevation of the outlet weir on the west side of the aeration sump is 1005 feet. The 72-inch diameter lines from each side combine into one 72-inch diameter cement-lined steel pipe (CCP) to supply the hatchery. A slide gate is installed in the sump before each outlet and is kept completely open. A flow totalizer (Envirotech, Sparling Division) is installed on the supply line to the hatchery, but flows are never recorded and flowrates are never determined.

Hatchery staff report that algae and other debris plug the packing inside the columns. Maintenance personnel attempt to clean the packed columns every year, but sometimes columns are only cleaned every 2–3 years due to hatchery operation and time constraints. The sump portion of the aeration tower is not cleaned often. Both sides were cleaned in 2007 for the first time in 15 years and an estimated 52 tons of sand was removed. A yearly sump cleaning regime is currently under development by the maintenance staff. As constructed, both sides of the aeration sump floor slope away from the outlet side to an 8-foot deep trough that runs the width of the sump near the inlet side. An 18-inch diameter drain line is located in the corner of each trough, which connects to a pump sump area located near the main overflow line. The system could be used to drain the aeration sump completely and could potentially be used to remove any solids collected in the troughs; however, no pump is currently installed in the pump sump area. If the system were used, any sediment in the bottom of the aeration tower sump would be discharged directly to the North Fork of the Clearwater River unless it is captured and diverted to a different location.

Mechanical Building 1

Mechanical Building 1 was constructed during the initial phase of hatchery construction to provide heated water for incubation and early life rearing stages. The building contains a 1,500 gpm heat exchanger/boiler system, which is primarily used to heat reservoir water for use in the incubation room and to provide radiant heating in the hatchery buildings. In the past, the heat exchanger system was also heavily used to supply the nursery room with heated reservoir water; however the system did not have the capacity to meet the entire heated water need for both the incubation and nursery rooms. The reservoir line was extended to the heating system in Mechanical Building 2 in 1991, and that system currently supplies most of the heated water to the nursery room. However, the Mechanical Building 1 heating system can be used to supply one bank of tanks in the nursery room if required.

Reservoir water gravity-flows into a pump sump located in the corner of Mechanical Building 1. The sump has five vertical turbine pumps, although typically only two pumps are used at one time. Three of the pumps have 60-HP motors and the two older pumps have 15-HP motors. The pump sump has an emergency overflow, but does not have a drain and is in use most of the year. Reservoir water from the sump is pumped through one of three tube and shell heat exchangers. Piping allows for water to be pumped through any one of the three heat exchangers, but the units cannot be bypassed. Warm water is supplied to the heat exchangers from two electric boilers that are operated in a closed-loop configuration. Two 15-HP pumps are used to pump water through the boilers and heat exchangers. The boiler pumps are original to the hatchery, but have no reported operational problems. Water flowrates through the heat exchangers are regulated using air-operated valves (DeZurik Water Controls) that are automatically adjusted to maintain the water temperature set point for the system. The air compressor that controls the system valves is located in Mechanical Building 1 and has few maintenance requirements.

Mechanical Building 2

Mechanical Building 2 was built during the second phase of hatchery construction in 1972 with pumping, filtration, disinfection, and heating systems to treat river water for makeup addition to the Burrows ponds reuse systems. The building underwent significant renovations after the reservoir line was extended to the building in 1991. The building is currently similar to Mechanical Building 1, but larger, with five heat exchangers and four electric boilers. Mechanical Building 2 currently supplies the heated water requirements for the nursery room, as well as heated makeup water for the Burrows ponds reuse systems when they are in operation. Typically only two of the three reuse systems are operated each year due to differences in fish size and growth.

When operated to heat makeup water during reuse, Mechanical Building 2 provides 1,500 gpm for reuse System I, 1,500 gpm for System II, and 2,000 gpm for System III. Mechanical Building 2 is also used to provide 1,200–5,120 gpm of heated water for the nursery tanks from January through May when the reservoir water is below 54°F. Water enters Mechanical Building 2 and flows through one of three old open-channel electric grid purifier units and into an in-ground sump (Figure 9). The purifiers were installed as part of the original river water treatment system in Mechanical Building 2. The electric grid systems were removed from the purifiers during building renovations; however the unit enclosures remain. Stagnant water typically sits in the purifier units and pump sump from June through November when Mechanical Building 2 is not in use.

Figure 9. Old electric grid purifier unit outlets to pump sump in Mechanical Building 2.

The pump sump is nine feet deep with a maximum operational water depth of seven feet, and has a high water level alarm. The sump also has a 14-inch diameter emergency overflow to the river, but does not have a drain. The pump sump has four 125-HP vertical turbine pumps; however no more than three pumps are operated at one time. Pumps are original to the construction of the mechanical building and were all manufactured by the Peerless Pump Company. Pump operation is manual on/off. Piping in Mechanical Building 2 allows the use of any heat exchanger. The electric boilers provide hot water to the heat exchangers in a closed-loop system using four 50-HP pumps. Mechanical Building 2 has an automatic temperature control system identical to that in Mechanical Building 1. Hot water flowrates through the heat exchangers are adjusted with air-operated control valves (DeZurik Water Controls) to maintain the water temperature set point. Two air compressors located in the building provide air for operation of the heat exchanger control valves.

Heated water for the nursery rearing tanks is directed to one of two nursery head tanks located outside near the System I biofilter units (Figure 10). The outdoor nursery head tanks do not have any degassing treatment equipment, but the nursery rearing tanks currently have individual packed columns above each tank. The head tanks are insulated and an above-grade operational water level of 20.67 feet is maintained in the tanks, providing a constant water pressure of approximately 16 feet to the nursery tanks. The nursery head tanks are each 24.17 feet high and 15.92 feet in diameter, providing a combined operational volume of approximately 30,800 gallons.

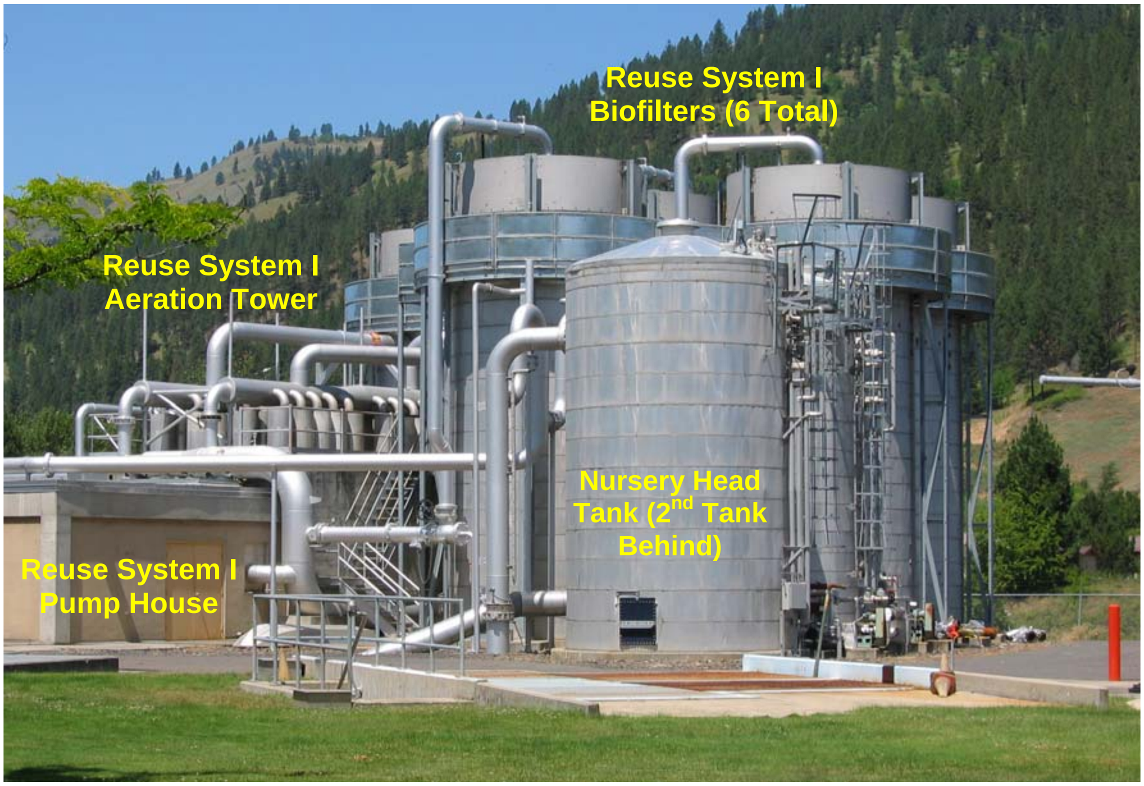


Figure 10. Nursery head tanks adjacent to reuse System I treatment equipment.

Heated makeup water that is used in reuse System I is directed to the system's reuse pump sump and is degassed with the full reuse process flow. Heated makeup water in reuse Systems II and III is directed to one of two degassing towers located outside next to Mechanical Building 2 (Figure 11). System II and III each have individual covered degassing towers with packed columns at the top. Both towers are approximately 21 feet tall and 7.33 feet in diameter. After treatment with the packed columns, water stored in the towers gravity-flows to combine with reuse water in the respective system's Burrows pond reuse supply line. The operational water level in both towers is approximately 17.5 feet. The towers are insulated and each one has an overflow line and is typically drained when not in use.

The packed columns for both systems are covered, non-vented, and approximately 6.5 feet high and 24 inches in diameter. The columns have several sets of splash screens with random packing in between the screens. The System II tower has four packed columns at the top and the System III tower has six packed columns. Assuming even distribution of the 1,500 gpm heated System II makeup water flowrate, the hydraulic loading rate to each of the System II columns is approximately 120 gpm/ft^2. The columns on the System III tower have a slightly lower hydraulic loading rate of 106 gpm/ft^2 assuming even distribution of the 2,000 gpm heated makeup water flow for that system.

Figure 11. Heated makeup water degassing tower for System II (foreground) and System III (background) adjacent to Mechanical Building 2.

<u>Facility Design</u>

An overview layout of Dworshak NFH is provided in Figure 12. Fish rearing at Dworshak NFH takes place indoors within the incubation and nursery building, as well as outside in the Burrows ponds and raceways. The hatchery has a total of 30 outdoor raceways, nine holding ponds (five have been modified into ten raceways), and 84 Burrows ponds. The Burrows ponds are arranged into three different systems: System I has 25 ponds, System II has 25 ponds, and System III has 34 ponds.

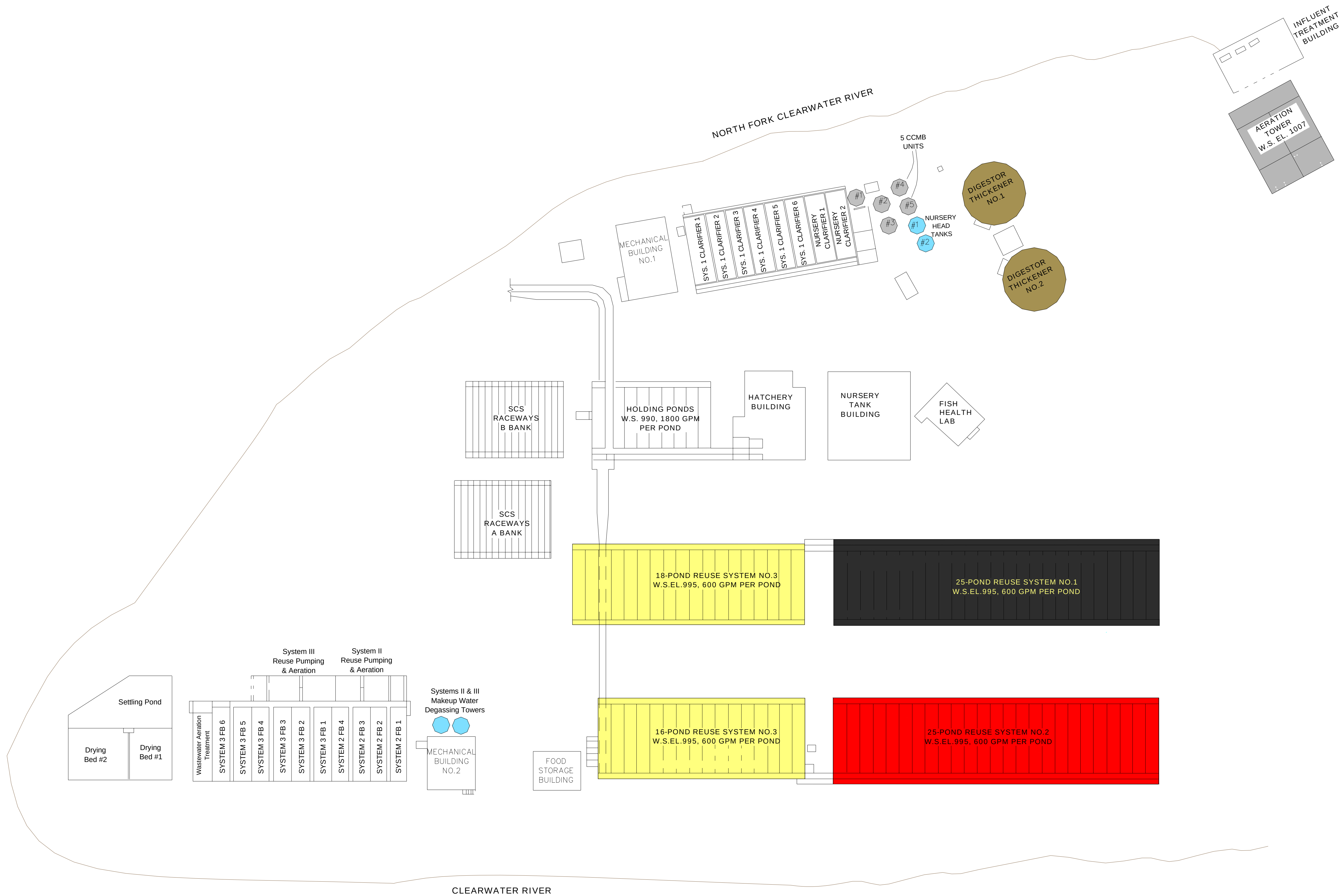


Figure 12. Dworshak NFH layout.

Hatchery/Nursery

Hatchery

The process flow diagram for the incubation room is shown in Figure 13. The incubation room has a 5.5-foot diameter head tower with five packed columns at the top. The packed columns are six inches in diameter and 4.5 feet tall, and each column is fed with a 2-inch diameter line. Heated reservoir water from Mechanical Building 1, chilled reservoir water, and ambient reservoir water can be used in the incubation room. These water supplies can be mixed at the incubation room head tower; however, only heated water from Mechanical Building 1 is treated with the packed columns at the head tower. The operational water level in the head tank is ten feet above the finished floor of the incubation room. The head tower has a level switch that provides an alarm notification of low level events through the hatchery's main alarm system.

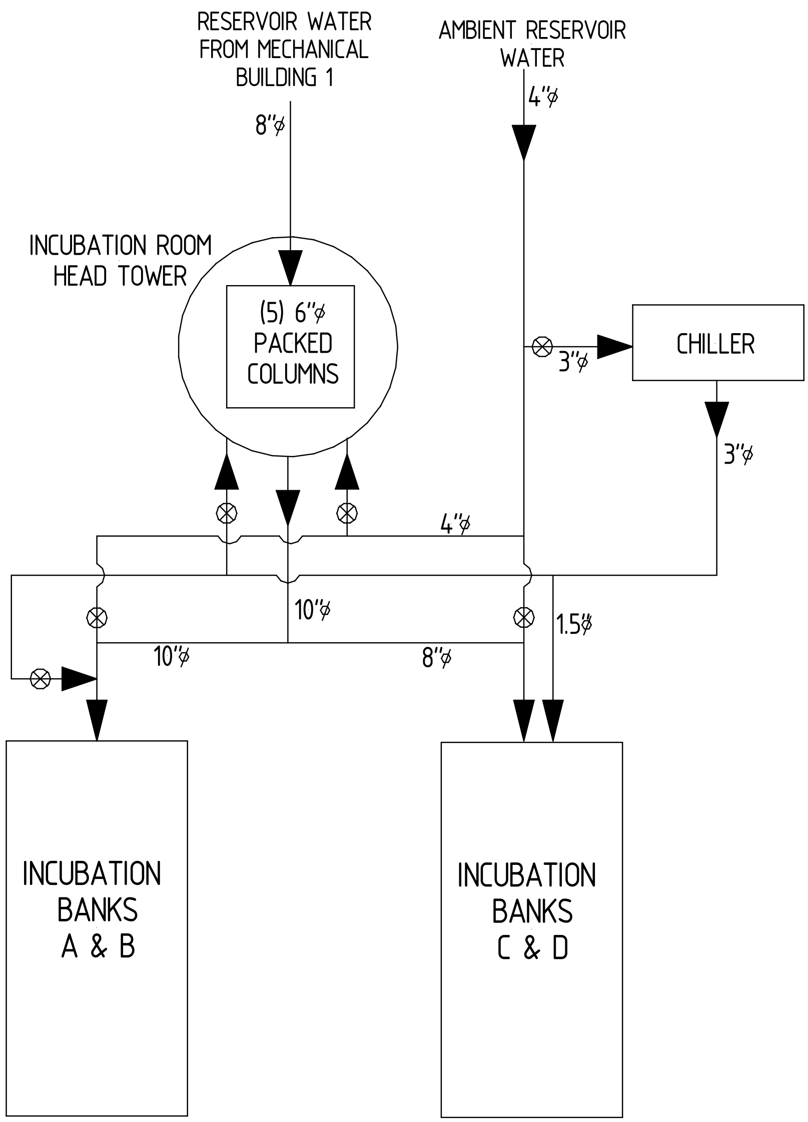


Figure 13. Incubation room process water supply flow diagram.

The incubation room chiller is used to cool ambient reservoir water to 37–38°F for incubation of Chinook salmon eggs in order to slow egg development by approximately 2–3 months. The chiller is not a new unit, but was refurbished in 2005 when it was installed in the incubation room. The maximum flowrate used in the incubation room is 450 gpm, but water use is only 200 gpm on average.

The incubation room has 58 double stacks of standard vertical tray incubators that are used for all of the programs at Dworshak NFH (Figure 14). Each incubation stack has eight trays, although the first tray of the top stack is used for solids settling and is not used for egg incubation. Incubation stacks are arranged into four banks. Banks A and B each have 17 double stacks of incubators and Banks C and D both have 12 stacks. The typical water supply flowrate to each double stack is 4 gpm.

Figure 14. Vertical tray incubation stacks in the incubation room.

An automatic formalin dosing system is installed in the incubation room to administer prophylactic formalin treatments to the stacks. The system is manually turned on, at which time formalin is pumped from a bulk storage container to the top of the incubation stacks and metered into the water supply as it is delivered to each stack. The formalin pump system is on a timer and turns off after 15 minutes of operation. Incubation stack effluent discharges to a trench drain underneath the stacks, which discharges into a storm drain and then to the river without treatment or screening. There are no separate formalin drain lines. Formalin is typically used in the incubation room from January–June for steelhead eggs, August–December for Chinook eggs, and October–December for Coho eggs.

The incubation room also has four 6-foot diameter, 3-feet deep circular tanks that are used from March until May to pond rainbow trout fry. Additionally, the incubation room has four rectangular nursery tanks and a long trough with an old colander-type egg hatching system, none of which are currently used. When in use, reservoir water from the incubation room head tank supplies water to these systems as required.

Nursery

The nursery building was built with 64 concrete tanks during the initial hatchery construction. The size of the nursery building was doubled when construction of an addition was completed in 1980. The building has a wooden roof that is currently in need of replacement, which is scheduled to be completed by the USACE in the fall of 2008 when the nursery tanks are empty. The nursery room currently has 128 rectangular tanks that are arranged into four banks (A–D); each bank has two rows of 16 tanks. Half of the nursery tanks are concrete and the remainder are fiberglass. Concrete tanks are 3 feet wide, 16 feet long, and 1.9 feet deep with an operational water volume of 682 gallons. Fiberglass tanks are 3 feet wide, 16 feet long, and 1.8 feet deep with an operational water volume of 643 gallons (Figure 15).

Figure 15. Fiberglass nursery tanks with individual packed columns.

Water supply lines enter the nursery building at four locations along the wall to supply each of the four banks of nursery tanks. River water is never used in the nursery building. Heated reservoir water is used in the nursery for most of the year, but ambient reservoir water is used starting near the end of May when water temperatures warm up to above 54°F. Process piping to the nursery building allows the direct use of ambient reservoir water in any of the tanks. Heated reservoir water directly from Mechanical Building 1 can be used in the A bank of tanks, but is not typically used in the nursery tanks due to insufficient system heating capacity. Heated reservoir water from Mechanical Building 2 is typically used in the nursery building. Process piping does not allow heated water from Mechanical Building 2 to flow directly to the nursery building; it is directed to the outdoor nursery head tanks and then flows by gravity to the nursery building. Water temperatures in the nursery room are continuously measured and recorded at three of the water supply manifolds. The total water use in the nursery room is 5,120 gpm when all of the tanks are full.

Water is treated with packed columns above each nursery tank. Packed columns are six inches in diameter and four feet tall, filled with Tellerette® plastic media. At a water supply flowrate of 40 gpm, the hydraulic loading rate for each packed column is approximately 205 gpm/ft^2, while the recommended loading rate is 40–100 gpm/ft^2 (Colt and Bouck, 1984). Hatchery staff members have not observed ill-effects of nitrogen saturation on fry in the nursery room, however dissolved gas readings collected in November 2007 indicate higher than desirable levels for steelhead fry (Table 2). Average measurements indicated ambient reservoir water after treatment with a nursery tank packed column remained super-saturated with dissolved nitrogen at 103%. Heated reservoir water (54°F) prior to treatment with a nursery tank packed column had a dissolved nitrogen content of 113% of saturation, which was reduced to 104% after treatment with the nursery tank packed column.

Most of the tanks in the nursery room are used from January through August for steelhead fry. Approximately 16 tanks are made available from January through March for the Nez Perce tribe to raise Coho salmon fry. The Tribe ponds the Coho salmon in the nursery tanks after hatching in the incubation stacks. For the steelhead program, hatching jars are installed at the head of each rectangular tank and eggs are placed into the jars after eyeing-up in the incubation stacks. Heated reservoir water enters each egg jar at approximately 5 gpm. Eggs hatch approximately 4–5 days after being put into the jars and sac-fry swim out of the top of the jars into the rectangular nursery tanks. The water supply to each tank is gradually increased to 40 gpm after the eggs hatch, and the hydraulic residence time per tank is approximately 16–17 minutes. Rearing space limitations in the nursery room are a concern for the steelhead program. Eggs from the last three spawning events must be returned to the vertical tray incubation stacks after eye-up until some of the young steelhead in the nursery tanks are old enough to be moved outside. Hatchery staff estimate another 32 tanks are needed in the nursery room to accommodate the remaining eggs and fry for the steelhead program.

All of the nursery tanks have small quiescent zones with effluent standpipes. Tanks are cleaned and brushed on a daily basis, and tank effluent is collected in trench drains. Trench drains from the nursery room combine into a 12-inch diameter drain line, which drains to clarifiers #7 and #8 for treatment prior to being discharged to the North Fork of the Clearwater River.

Broodstock/Growout

Receiving and Holding Ponds

Nine concrete holding ponds were constructed at the top of the facility's fish ladder during the initial phase of hatchery construction. The entrance to the fish ladder is on the North Fork of the Clearwater River. Effluent from System III Burrows bonds and/or the holding ponds provide the operational and attraction water for the ladder. Broodstock that return to spawn in the North Fork swim up the fish ladder into a trap that is located in the channel between the holding ponds and fish ladder. Currently when the fish trap is full, the broodstock are crowded into holding pond #9. Depending on the program and time of year, broodstock are kept in holding pond #9 or transferred to holding ponds #1–3. Five of the holding ponds, #4–#8, have been converted into ten raceways for the Nez Perce Tribe to raise Coho salmon smolts.

The holding ponds are 17.67 feet wide, 75 feet long, and 9.5 feet deep. The water level in the ponds is maintained at approximately 5.75 feet with damboards. Two concrete channels are located in front of the holding ponds: the channel closest to the holding ponds is a fish transfer channel that connects to the hatchery building and the other channel is used for water supply distribution to the ponds. When it is time for spawning, broodstock in the holding ponds are crowded through the fish transfer channel to the spawning room in the hatchery building.

River water from the main aeration tower is used as the water supply source for the holding ponds. Water is introduced through a concrete diffuser inlet underneath the pond floor in holding ponds#1, 2, 3, and 9. Supply water from the holding pond influent channel enters each diffuser inlet structure through a 36-inch diameter gate valve and supply line. Approximately 5,000 gpm is supplied to the receiving pond and 1,200 gpm is supplied to each of the first three holding ponds. Effluent from the holding ponds and converted raceways is discharged directly to the North Fork of the Clearwater River through the ladder and attraction channel.

Burrows Ponds

Dworshak NFH has a total of 84 concrete Burrows ponds arranged into three different systems. Each system has the infrastructure and equipment for operation under water reuse configuration. The Burrows ponds in System I were constructed for reuse during the initial hatchery construction and reuse equipment was added in Systems II and III during the second phase of construction. In Systems I and II, Burrows pond effluent is collected in one of two concrete effluent drain channels that run perpendicular to the ponds: one channel drains directly to the river and the other transfers pond effluent to the corresponding system's reuse treatment equipment. The plan and section view of a Burrows pond with both effluent channels is illustrated in Figure 16. The pond effluent reuse channel in System II conveys effluent to the system's channel pump sump, while the reuse channel in System I conveys pond effluent directly to the System I clarifying basins. System III only has one concrete effluent channel running perpendicular to the Burrows ponds. Valves are utilized to direct pond effluent in the single channel to either the system's channel pump sump for reuse operation or to the Clearwater or North Fork Rivers for discharge.

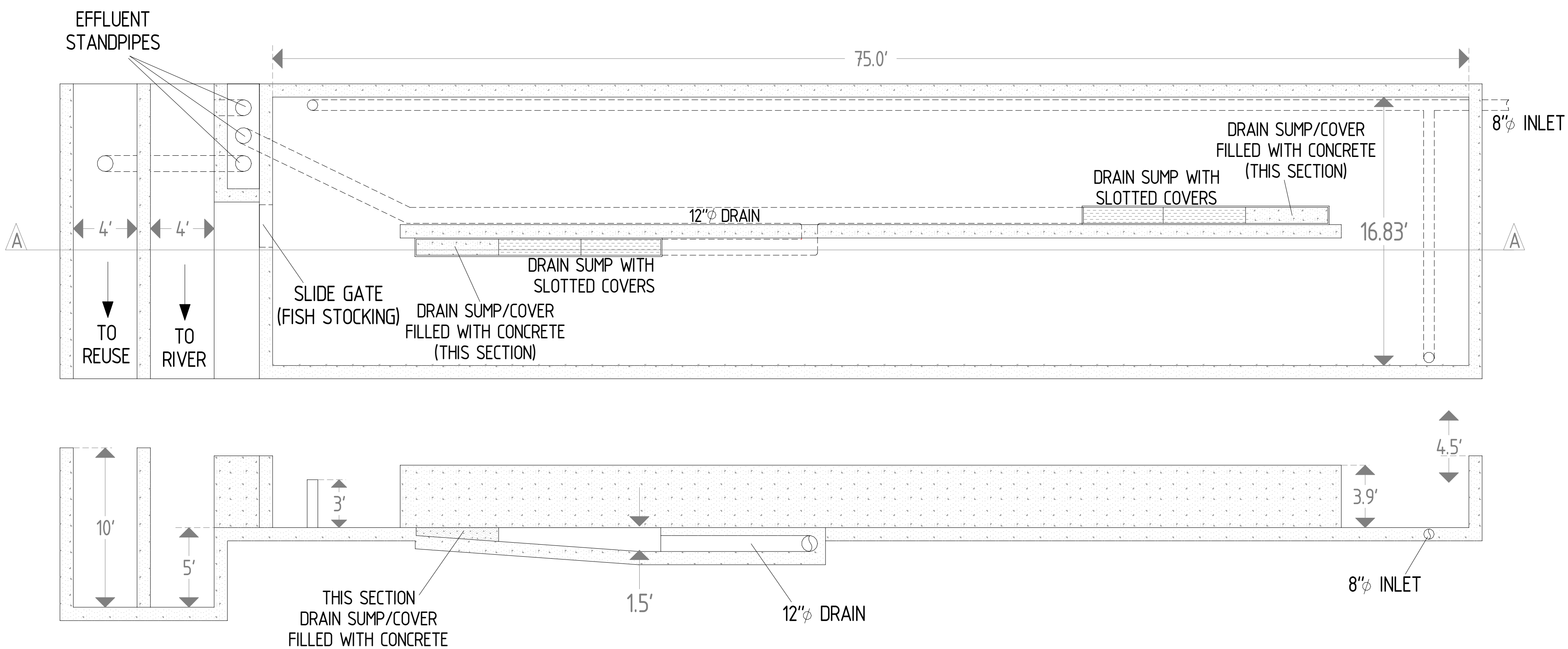


Figure 16. Illustration of outdoor burrows ponds in Systems I and II at Dworshak NFH. System III burrows ponds are dimensionally identical, but have only one effluent channel.

Burrows ponds are 75 feet long and 4.5 feet deep with an estimated rearing volume of 23,980 gallons at an operational water level of 2.5 feet in each pond. Each pond has an external standpipe to maintain the water level in each pond. Ponds in Systems I and II also have one standpipe that controls the drain to the effluent channel, which flows to the river, and one standpipe that controls the drain to the system reuse effluent channel. System III ponds have a third standpipe since theses ponds have only one effluent channel. Every pond has a slide gate that opens directly to the river effluent channel to enable stocking of fish from the ponds to the Clearwater River.

Water supply flowrates are not routinely measured at Dworshak NFH; however, water supply flowrates typically vary from approximately 450 to 600 gpm per pond. The Burrows ponds were each designed to receive a water supply flowrate of 600 gpm, but suspected blockages in valves and supply lines reduce the supply flowrate that some of the ponds actually receive. Hydraulic retention times in the ponds vary from 40 to 55 minutes over the speculated flow ranges. Each pond has an 8-inch diameter inlet line that supplies two 4-inch diameter inlet risers, which are located in opposite corners of the pond as shown in Figure 16. Inlet risers are 3-feet high and each is fitted with seven 1-inch diameter nozzle jets. The inlet risers were designed to have a jet velocity of 17.5 ft/sec at the riser design flowrate of 300 gpm, which would produce a velocity of 0.85 ft/sec along the outside pond wall midway down the length of the pond. Current operational jet velocities are visually less than the design point.

Effluent from each pond drains through one of two rectangular drain sumps located on opposite sides of the center dividing wall. As constructed, these sumps are approximately 15 feet long and 1 foot wide, and are covered with slotted aluminum fish exclusion screens. The bottom of each drain sump is sloped approximately 3.6% to a 12-inch diameter steel bottom drain line (SCH 40). The bottom drain lines are oversized for the flowrates used in the ponds, resulting in low velocities and ineffective solids movement through the drain lines. Assuming 500 gpm is supplied to each pond and exits both drain sumps equally, the velocity in the 12-inch diameter drain line from one drain sump is less than 0.75 ft/s. After the individual 12-inch sump drain lines combine into one 12-inch line for the pond, the velocity is 1.4 ft/s, which is closer to the 2 ft/s optimum velocity to transport solids through drain lines. The velocities at the design pond water supply flowrate of 600 gpm results in more optimal drain line velocities of 0.85 and 1.7 ft/s in the 12-inch diameter drain line for individual and combined drain sumps, respectively. Fish feces and uneaten feed most likely remain in the drain sump and piping where there are low water velocities for solids transport, degrading into smaller particles and leaching nutrients into the effluent and producing poor water quality within the ponds.

Modifications to the Burrows pond drain sumps in the 1980s attempted to reduce solids accumulation within the drain sumps. These modifications entailed plugging the first five-foot section of each pond drain sump with concrete, as indicated in Figure 16. The modification was intended to increase the velocity through the drain plates into the drain line by decreasing the surface area of the drain sump available for effluent. A higher velocity would increase the attraction of solids to the slotted drain plates and through the drains. The modifications may have achieved the intended result, but also produced large dead spaces at the end of each wall near the plugged drain sump area. Personal observation indicates that the water does not move in this area and results in a large accumulation of waste solids, as seen in Figure 17. Waste solids remain in the dead zone until they are physically removed by hatchery staff.

Ponds are currently brushed weekly and solids are flushed directly to the river. Flushing solids from the ponds is problematic due to poor hydraulics and it is difficult to get solids to move into the drain. Slots in the fish exclusion plates over the drain sumps also reportedly become plugged with solids during pond cleaning and flushing. During the summer of 2007, hatchery staff modified the AquaMat® product into floating sweeper units to facilitate the continuous movement of solids in the ponds (Figure 17). The AquaMat® sweepers are intended to move around the ponds in the direction of the water flow, moving waste solids along the pond bottom and closer to the drains. Each pond has three to four sweeper units, and hatchery staff members have indicated a reduction in waste accumulation in the ponds when using the sweepers. The AquaMat® sweepers are subject to the hydraulic flow patterns within the ponds and occasionally become trapped in the dead zones.

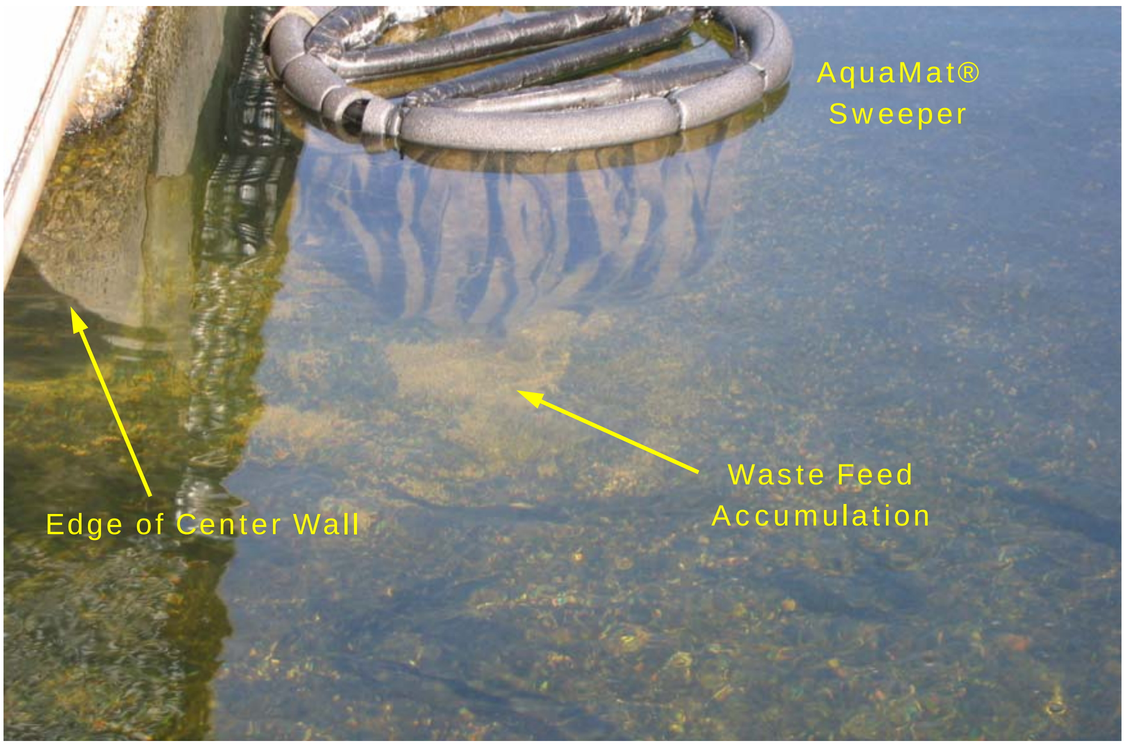


Figure 17. Waste feed accumulation in Burrows pond near drain sump dead zone with AquaMat® sweeper in background.

System I

Fish culture rearing space in System I consists of 25 Burrows ponds. The System I water reuse process flow diagram is provided in Figure 18. When not operated in water reuse, System I pond effluent is discharged directly to the Clearwater River. When operated in reuse configuration, effluent from System I ponds is directed to the reuse effluent channel at the end of the ponds and gravity-flows to one of six clarifying basins (Figure 19).

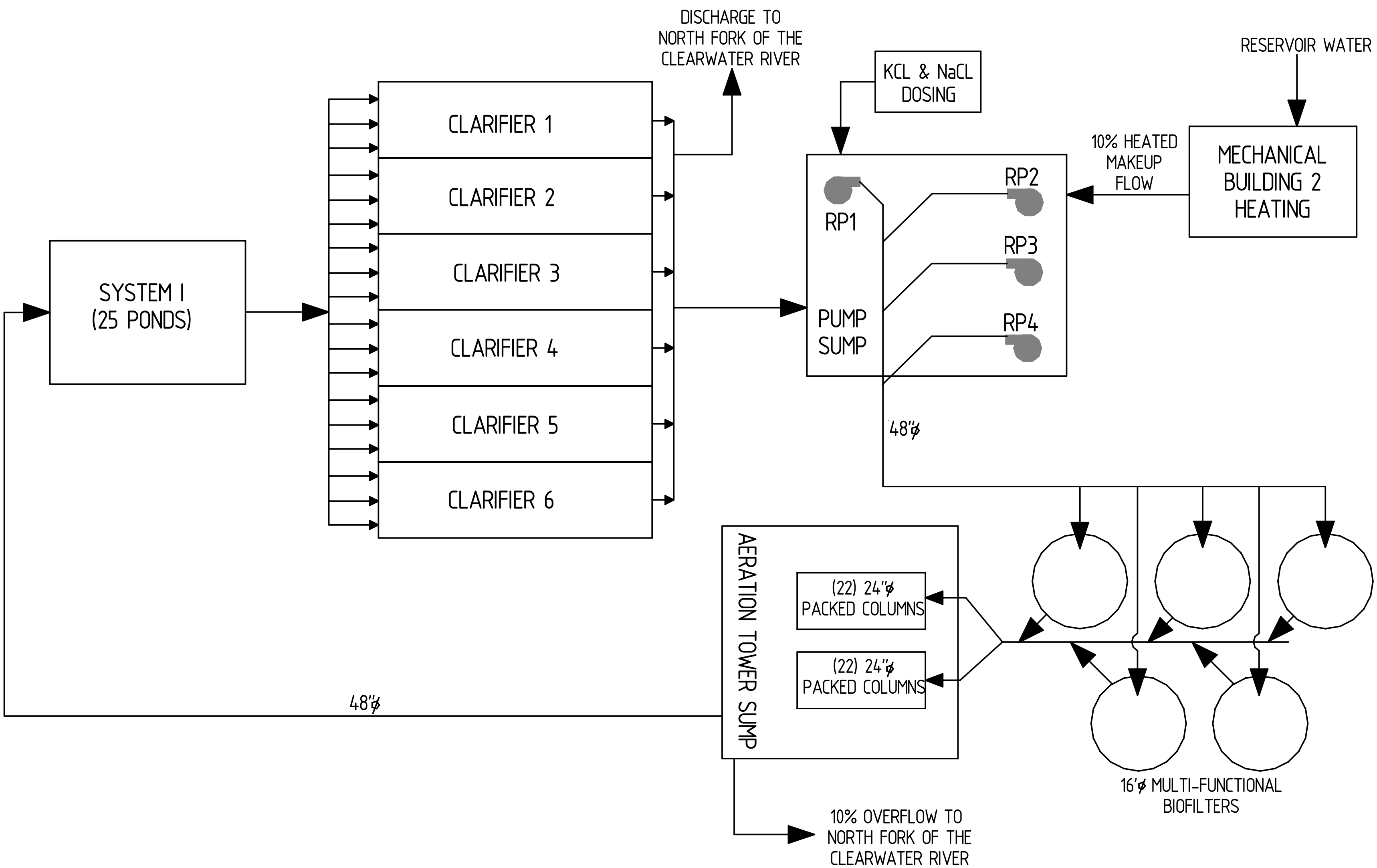


Figure 18. Reuse System I process water flow diagram.

Unlike the other two reuse systems, System I does not require intermediate pumping from the Burrows ponds to reuse treatment equipment. System I pond effluent is collected into a 48-inch diameter drain line, which is reduced to 36 inches before reaching the clarifying basins. A 4-foot wide concrete influent channel in front of the clarifying basins distributes water into individual basins through one of three inlet valves. Water is further distributed evenly over the width of the each basin as it flows through slotted openings in a concrete influent weir wall. The water level is maintained in each basin with an effluent fingerweir, as shown in Figure 19. The finger portions of the effluent weir increase the overall weir length and results in a lower exit velocity from the basins, which is desirable to minimize turbulence. Inlet valves must be adjusted independently to maintain equal loading rates to each basin based on the effluent weirs.

Figure 19. System I clarifying basins.

When the hatchery was first constructed, the System I clarifying basins were filled with stone and oyster shell media to remove solids and also serve as biofilters for the system. The basins were modified to their current state in the 1980s when sand biofilter vessels for System I were also constructed. Clarifying basins are approximately 75 feet long and 22.5 feet wide with an operational water depth of 6.25 feet. Assuming full-flow conditions and equal flow dispersion of the 15,000 gpm maximum System I flowrate among all six basins, the resulting overflow rate per basin is 0.004 $ft^3/ft^2/sec$. The Idaho Waste Management Guidelines for Aquaculture Operations (1998) recommends full-flow settling basin overflow rates less than 0.013 $ft^3/ft^2/sec$ for settling solids in aquaculture wastes.

A chain-and-flight sludge scraper system is installed at the bottom of each clarifying basin. The system consists of rigid wooden flights, which span the width of the basin, attached to a pair of chains. The wooden flights are approximately ten feet apart and scrape settled solids down the length of the basin into a concrete trough at the influent end as the chains rotate. The scraping systems were designed to run continuously; however they are only operated once a day because settled solids are stirred up when they are operated. Chain-and-flight sludge scraper systems are fairly common in municipal wastewater operations where solid waste particles are heavier than those from aquaculture facilities. An auger-type screw conveyor system transfers scraped solids from the concrete channel to a pumpout area underneath the clarifying basins. The settled solids are pumped daily to one of two nearby uncovered digester tanks for storage (Figure 20). Solids are pumped to the storage tanks using one of two centrifugal solids pumps located underneath the clarifiers; one pump is typically used while the other serves as a backup. Both 5-HP pumps are rated for 500 gpm against 19 feet TDH and have a 6-inch diameter discharge line to the outdoor digesters. The sludge line was refurbished by the USACE in 2002 and is now PVC.

The solids storage/aerobic digester tanks are 45 feet in diameter and 14.75 feet high with an operational storage volume of approximately 155,000–200,000 gallons each (Figure 20). Each digester has a submerged paddle wheel in the center for tank mixing and a diffused air system around the interior wall of the tank for aeration. A pumping system with two 7.5-HP sewage pumps is located in a building between the digester tanks that allows sludge to be recirculated between the two tanks. The aeration and recirculation systems are not used, but can be operated on a timer if desired. Supernatant from the digester tanks can be discharged to the North Fork of the Clearwater River through outlet 001 with effluent from the clarifying basins. The current hatchery operational plan entails transferring the digester contents to one of the hatchery's drying beds with a hauling truck and then using dried solids for fertilizer.

Figure 20. One of two System I solids storage/aerobic digester tanks.

Clarified effluent from each basin can be directed to a concrete channel that drains directly to the North Fork of the Clearwater River through a 24-inch diameter drain line, or can be used in the reuse system. Clarified effluent from each basin that is reused within the system combines into a 30-inch diameter process water reuse line that runs along the influent side of the clarifying basins and feeds the reuse pump sump in an adjacent pump house building. The reuse pump sump has four vertical turbine pumps, but only three are typically used when the system is in operation. Each pump has a 125-HP motor and is rated to pump 5,000 gpm against 72 feet TDH. Heated makeup water is added directly to the reuse pump sump from Mechanical Building 2. The pump sump has a low level water alarm connected to the main hatchery alarm system. The sump does not have an overflow and cannot be drained.

Sodium chloride (NaCl) and potassium chloride (KCl) are added directly to the reuse pump sump. Two separate dosing systems, each with two dosing pumps, are located within the System I maintenance building near the pump sump; new dosing systems were installed in 2006. Sodium and potassium salts are added to the system reuse water to reach target chloride concentrations of 45 mg/L, while maintaining a 2.5 to 1 ratio of sodium to potassium. Research conducted at Dworshak NFH by Bradley (1984) in the late 1970s indicated a decrease in gill swelling and mortality with the addition of these salts during reuse system operation. The author attributed the decreased mortality to the affect of the salts on decreasing unionized ammonia concentrations in fish culture water. Levels of ammonia, sodium, and potassium are measured in the reuse systems 2–3 times per week during operation of the dosing systems. Chloride levels are calculated based on sodium and potassium measurements. Stock minerals are stored underground adjacent to the maintenance building.

Reuse water in the System I pump house sump is pumped to one of five continuous cleaning multifunctional biofilters (CCMB) manufactured by A1 Aquaculture (Bush, LA). Each 14-inch diameter biofilter inlet line has a flowmeter/flow totalizer (McCrometer; Hemet, CA), but flows are not recorded. Biofilter units are 16 feet in diameter and 35 feet high, filled with small, plastic, granular media. The media forms an expandable, fluidized bed when water is added to the unit and provides a surface area for nitrification. The System I bioreactor vessels were constructed during hatchery renovations in the 1980 as fluidized sand bioreactors; however they were only operated for 1–2 years after they were installed. In past years young steelhead from the first spawning events were put into System I Burrows ponds and the reuse system did not need to be turned on since the growing period for these fish was longer. As a result, the biofilter sand became very hard during the time the system was not used. The filters were retrofitted to the CCMB design in 2005–2006 and System I is currently operated in reuse configuration instead of System III.

Hatchery staff report operational problems with the CCMB units as media routinely expands too high and exits the units, plugging pipes and eventually ending up in the System I Burrows ponds. After treatment in the CCMBs, reuse water gravity-flows to an aeration tower that has 44 packed columns at the top. Packed columns are 5–6 feet tall and 24 inches in diameter, filled with pall ring packing. Assuming the 15,000 gpm reuse flow is distributed equally among all 44 packed columns, the hydraulic loading rate to one column is approximately 110 gpm/ft^2. The water level in the System I aeration sump is maintained at 12 feet, providing approximately 12.5 feet of head pressure to the Burrows ponds. Process piping allows clarified reuse water to be pumped directly to the System I aeration tower packed columns, bypassing CCMB units. System I was operated in reuse with the CCMB units for approximately one month during the 2007–2008 season before too many problems were encountered. After this time the System I ponds were still operated in reuse, but the CCMB units were bypassed and unionized ammonia nitrogen levels measured within the system remained low.

System II

System II has 25 Burrows ponds, which are located across from the System I Burrows ponds. The process flow diagram for the System II water reuse system is provided in Figure 21. During flow-through operation, pond effluent is collected in the river effluent channel and is discharged directly to the Clearwater River. During water reuse operation, Burrows pond effluent is collected in the reuse effluent channel and gravity-flows to the System II channel pump sump located on the west side of the System II ponds. The channel pump sump is L-shaped and has an operational water level of 4.83 feet. The channel pump sump has two 40-HP vertical turbine pumps that are rated to pump 10,000 gpm against 11.1 feet TDH. One pump has a constant-speed motor and the other pump has a VFD-controlled motor.

Reuse water is pumped from the System II channel pump sump to one of four floating media biofilter basins (Figure 22). System II biofilter basins are filled with floating granular kaldnes media (KMT). The biofilter basins for System II and System III are adjacent to one another, and were constructed during the second major phase of hatchery construction in the late 1970s. Each concrete basin is approximately 75 feet long, 25 feet wide, and 16 feet deep. When in operation, the basins are filled with 14.75 feet of water. The System II biofilter basins have two 18-inch diameter overflow lines that drain directly to the Clearwater River; one overflow line is shared by two basins. The invert elevation of the overflow lines is 12.25 feet above the basin floor.

An enclosed, rectangular, two-tier concrete channel is located between every two filter basins in Systems II and III. The channel is divided vertically; the bottom portion carries the pumped system reuse water for distribution in the biofilter basins and the top portion of the channel carries the treated effluent collected from each biofilter basin to the reuse system pump sump. The distribution channel has an interior width of four feet. The bottom portion has an interior height of 2.88 feet high and the top portion 5.67 feet. A 30-inch diameter sluice gate valve is located at the head of each filter inlet channel. Reuse water is distributed from the supply channel to each biofilter basin through one of three 8-inch diameter manifolds, which run along the bottom of the basin. Manifolds are located at equal distances along the length of the filter basin and have a gate valve at the bed entrance. All inlet gate valves are kept completely open during reuse system operation.

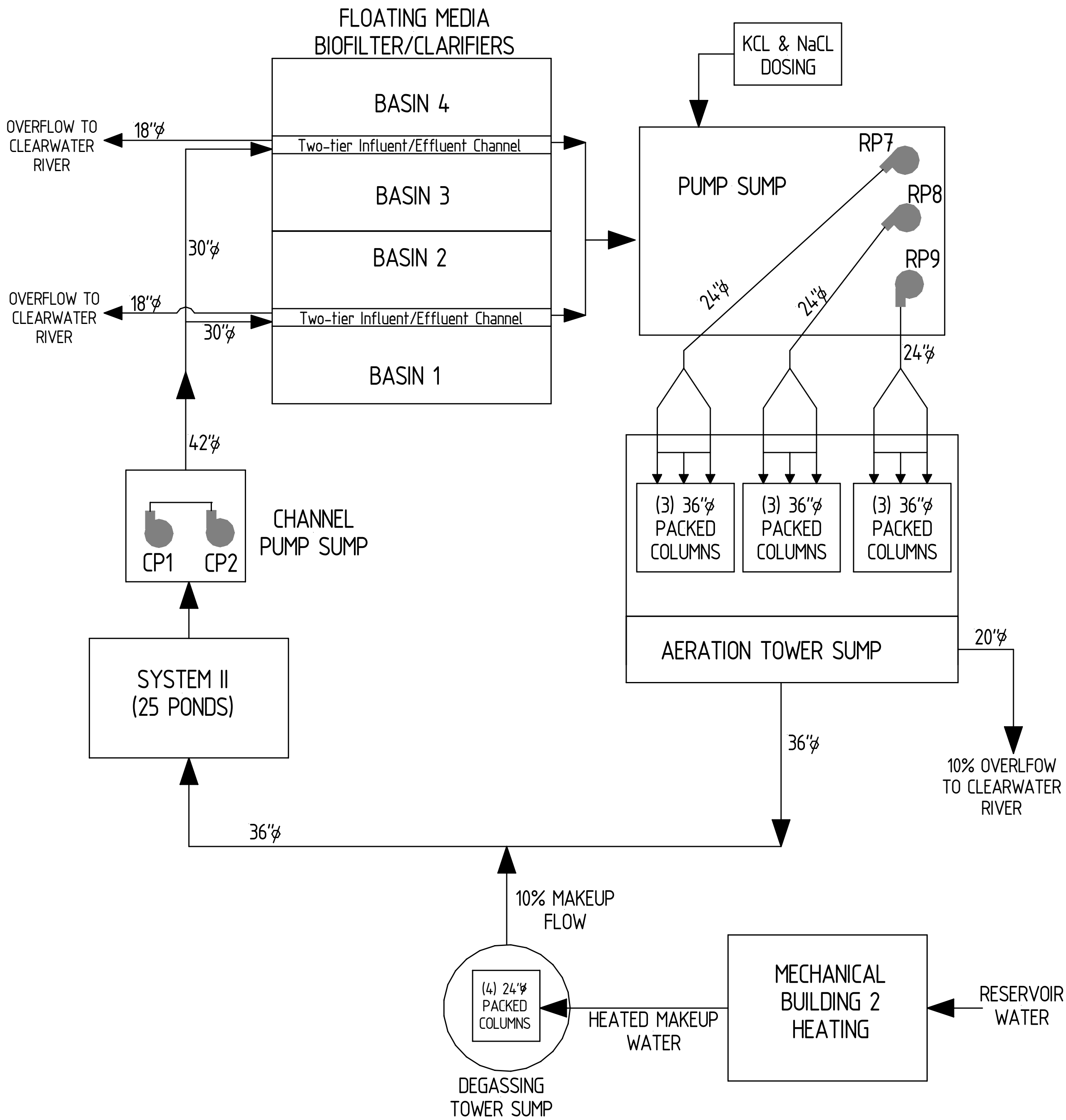


Figure 21. Reuse System II process water flow diagram.

Figure 22. System II biofilter basins with KMT-type floating media.

The KMT media bed floats within each bed and is approximately two feet deep. Water upwells from the supply manifolds through the filter media and treated water is collected in a grid of 4-inch diameter slotted PVC drain pipes. The drain pipes, which are capped and slotted to prevent filter media from exiting the beds, feed into aluminum effluent launderer channels. Aluminum channels span the width of each filter bed and connect to the top portion of the concrete filter distribution channel, which carries effluent to the reuse system pump sump by gravity. Each filter basin has four aluminum launderer channels that are approximately two feet wide and 1.5 feet deep. Slotted drain pipes run parallel to the concrete distribution/collection channel and aluminum effluent channels run perpendicular to the concrete distribution/collection channel. Filter basins have an air scour system that is operated manually as needed to dislodge solids from the filter media.

Chain-and-flight sludge scraper systems similar to those in System I clarifying basins are installed at the bottom of each biofilter basin in System II, spanning the basin width. Solids are scraped into a trough at the effluent end of the filter basins and pumped to the wastewater treatment basin adjacent to the west side of the System III basins along with scraped solids from System III. Unlike the clarifying basins in System I, biofilter basins in Systems II and III do not have auger-type screw conveyor systems to transfer solids to a central pump-out location. Operation of the scraping system has varied in the past, from running once a day for two-hour durations to running three times a day at 6-hour intervals. Scrapers take approximately one hour to complete one rotation, and problems with scraper flights bending are encountered when the systems are only operated once a day. Operation of the scraping and solids pumping system is manual. The KMT filter media must be removed from the System II basins in order to access the scraper assemblies for maintenance. The filter basins do not have drains and are full of water when not in use unless they are pumped dry.

The System II reuse pump sump is approximately 24 feet wide, 24 feet long, and 14 feet deep. The sump does not have a drain or overflow line, but the sump would overflow to the Clearwater River through the 18-inch diameter bed overflow lines at the front of the biofilter beds during an emergency. The operational water level in the reuse pump sump is 10.5 feet, providing a pumping volume of approximately 45,250 gallons. The sump has three single-stage vertical turbine pumps that are each rated to pump 8,500 gpm against 70 feet TDH; however pump impellers have been trimmed since their installation to provide 7,500 gpm each. Typical operation entails the use of only two of the pumps and the third is kept for backup and maintenance purposes. Pump operation is manual and pumps are operated at full capacity. Each pump manifold has a flow orifice to determine pumped flowrates; however the details of the orifices are not known and they are not used to determine flowrates.

Like System I, NaCl and KCl are added to the system reuse water directly in the reuse pump sump. Dosing systems are located within the System II maintenance building near the pump sump and stock minerals are stored underground adjacent to the maintenance building. Reuse water is pumped to one of nine packed columns located at the top of the System II aeration tower sump. Systems II and III share a concrete aeration tower structure, which is divided into two sections for the respective systems. The System II packed columns are six feet high and three feet in diameter, filled with 3.5-inch diameter ring packing. The hydraulic loading rate for each column is approximately 235 gpm/ft^2 assuming equal distribution of the 15,000 gpm flowrate among the nine packed columns. The aeration tower has a slide gate valve that is used as an overflow and to discharge 10% of the system flow to the Clearwater River. The 16-inch diameter System II overflow line combines with the overflow from the System III aeration tower into a 20-inch diameter cast iron line and discharges to the Clearwater River. The water level in the aeration tower sump is approximately 12.33 feet deep, providing a water pressure head of approximately 12.75 feet to the System II Burrows ponds.

Treated water from the System II aeration tower flows by gravity to the Burrows ponds via a 36-inch diameter cast iron supply line. Heated makeup water is added to reuse water in the 36-inch diameter line before the Burrows ponds. Makeup water for System II is heated using boilers in Mechanical Building 2 and then treated with one of four packed columns on top of the system's outdoor degassing head tower as previously discussed.

<u>System III</u>

System III contains 34 Burrows ponds. Steelhead are raised in 32 of the ponds and the remaining two ponds are used to raise rainbow trout. The 32 steelhead ponds are configured for water reuse operation. In past years, System III ponds were operated in reuse configuration for several months a year during the winter when the use of heated water is necessary, and fish in System III ponds always experienced more severe disease problems compared to other fish on station. Beginning in the winter of 2006-2007, System III ponds are not operated in reuse configuration; System I ponds are operated in reuse instead to avoid the disease issues. The reuse system equipment for System III is very similar to that in System II. A process water flow diagram for the System III partial reuse system is shown in Figure 23.

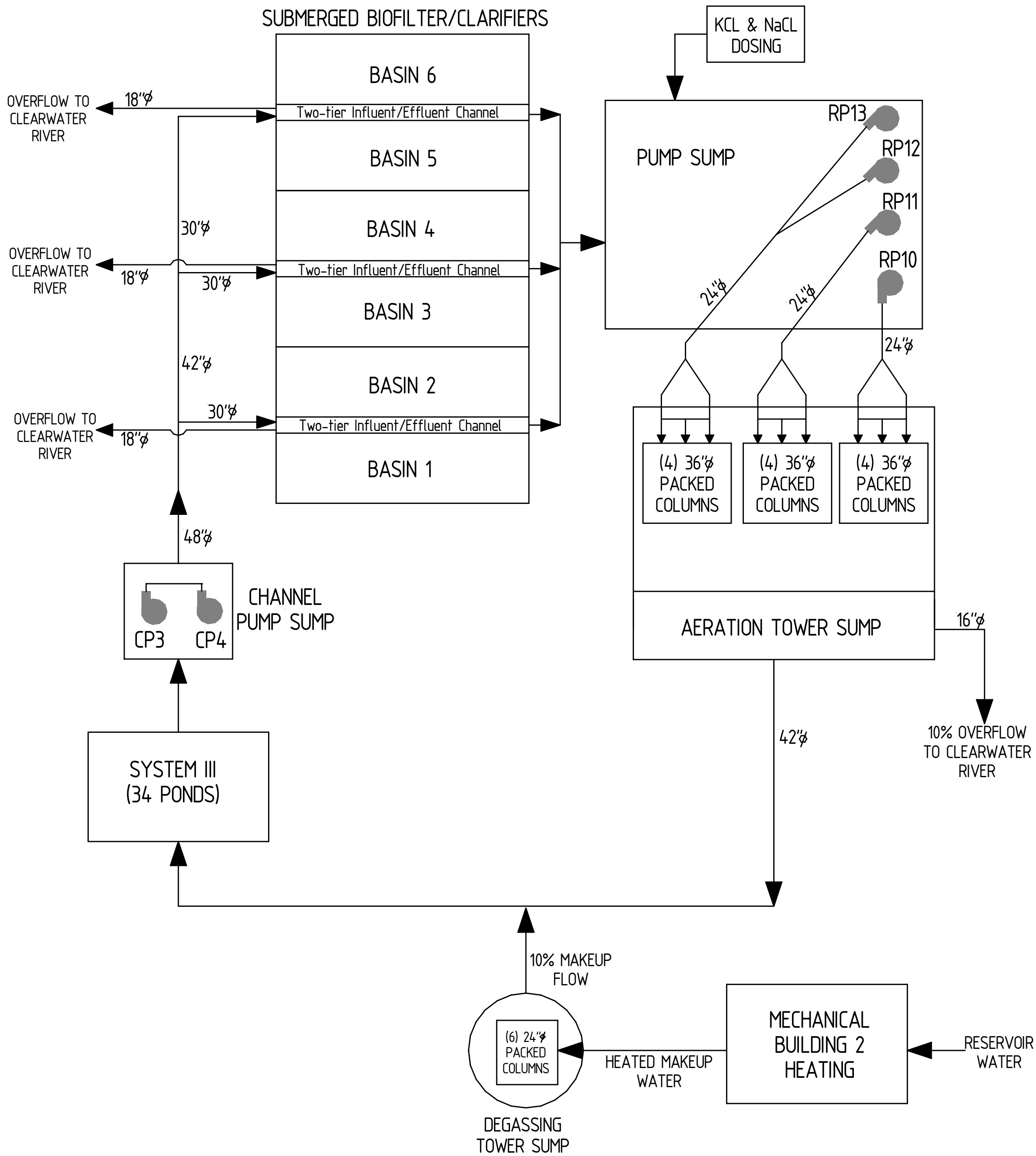


Figure 23. Reuse System III process water flow diagram.

System III Burrows pond effluent is collected in the concrete channel that runs perpendicular to the ponds and valves are used to direct gravity-flow effluent to the channel pump sump next to pond 82. Similar to System II, the channel pump sump in System III has two vertical turbine pumps, one with a constant speed pump motor and one that is VFD-controlled. Each pump is rated to pump 12,000 gpm and has a 50-HP motor. The VFD-controlled pump was refurbished in the summer of 2007. The channel pump sump is 11 feet wide, 11 feet long, and 12 feet deep. The operational water depth in the channel pump sump during use is 5.17 feet.

Reuse water is pumped from the channel pump sump to one of six submerged biofilter basins, which are filled with 3.5-inch diameter pall ring packing media to a depth of four feet (Figure 24). The size, shape, and basic operation of the System III biofilter basins are identical to System II beds as previously described. However, pall ring packing media in System III biofilter basins does not float and is suspended on wire mesh screens within each bed above the 8-inch diameter water inlet distribution manifolds. The chain-and-flight sludge scraper system is also located underneath the wire mesh screens, which allows for maintenance on the scraper system without removing the media.

Figure 24. System III submerged biofilter basins with pall ring packing media.

Operation of the System III sludge scraper systems is identical to System II. Like System II, the filter basins have an air scour system that is operated manually as needed to breakup solids on the pall ring packing. Scraped solids from System III are pumped to the wastewater treatment basin with System II solids using the same 7.5-HP pump. Solids accumulate within the submerged biofilter basins and are not effectively removed, which results in poor system water quality and provides a reservoir for pathogens. System III filter basins do not have drains and are full of water when not in use unless they are pumped dry.

In operation, water upwells from the filter supply manifolds through the pall ring packing media and treated water is collected in aluminum effluent launderer channels. Unlike System II, biofilter basins in System III do not have slotted PVC drain pipe grid systems to collect treated effluent since pall ring media does not float out of the filter basins. Like System II, each basin has four aluminum channels that feed into the effluent portion of the concrete distribution channel. Treated water from the biofilter basins gravity-flows through the channel into the System III reuse pump sump.

The System III reuse pump sump is approximately 14 feet deep, 24 feet wide, and 32 feet long. The operational water level in the sump is maintained at 10.5 feet, providing a pumping volume of approximately 60,300 gallons. Like System II, the reuse pump sump does not have a drain or emergency overflow, but water would overflow to the Clearwater River through the 18-inch diameter overflow lines at the front of the biofilter beds during an emergency. Access to the reuse pump sump is limited and the inside is never cleaned. The sump has four single-stage vertical turbine pumps that are each rated to pump 8,500 gpm against 70 feet TDH. Pump impellers were trimmed after installation and each pump now pumps 7,500 gpm. Pump operation is manual. Only three pumps are operated at one time and the fourth is used as required during maintenance of one of the other pumps. Pumps have 200-HP motors and 18-inch diameter impellers. Pump impellers were cast iron when the pumps were installed in the late 1970s, but were replaced with bronze after pumps experienced cavitation problems. Pump spacing within the sump appears to be adequate to prevent pump cavitation; however air bubbles or solids entrained in the process water reuse flow may potentially enter the pump sump from the biofilters. Pump bearings and other related parts are replaced every 5–6 years.

System III also has two dosing systems for addition of salts to the system reuse water in the reuse pump sump: one for NaCl and one KCl. Reuse water is pumped to one of 12 packed columns located at the top of the System III side of the reuse aeration tank. Each reuse pump manifold in System III has a flow orifice to determine pumped flowrates, but the orifice details are not known. Packed columns are 36 inches in diameter and filled with 3.5-inch diameter pall ring packing. Columns are divided into three sections that are each two feet tall, with an approximate gap height of 2.5 inches where the sections meet. Rust from the corroding cast iron water supply lines reportedly clogs the packing. The hydraulic loading rate for individual packed columns is approximately 235 gpm/ft^2 assuming equal distribution of the 20,000 gpm system flow among all of the packed columns. The aeration tower has a slide gate valve that is used as an overflow and to discharge 10% of the system flow. The overflow from the System III aeration tower is 16 inches in diameter and combines with System II overflow into a 20-inch diameter line that discharges to the Clearwater River.

Operational water depth in the aeration tower is 12.5 feet, which provides approximately 13 feet of water pressure head to the System III Burrows ponds during reuse operation. Treated water from the aeration tower sump gravity-flows through a 42-inch diameter line to the system ponds. Heated makeup water is added to reuse water in the 42-inch diameter line before the Burrows ponds. Makeup water for System III is heated in Mechanical Building 2 and is then treated for dissolved gases before addition to the reuse system water as previously described.

Raceways

Dworshak NFH has 30 concrete raceways that are used to raise spring Chinook salmon smolts. The raceways were constructed in the early 1980s and are arranged into two banks of 15 raceways. Raceways are typically operated as flow-through units; however process piping also allows effluent from the first bank of raceways to be directed to the second bank of raceways for operation as a two-pass system during emergency power situations. The raceways are in use for the majority of the year. They are only empty for 1–2 weeks in early April between year-classes of Chinook, which does not allow enough time for the raceways to be disinfected most years.

Raceways are 80 feet long, 8 feet wide, and 3.67 to 4.33 feet deep, sloping 0.8%. The operational water level of the raceways is maintained at an average depth of 2.83 feet using damboards, which provides an operational water volume of approximately 13,500 gallons. River water from the main aeration tower is used in the raceways. The typical water supply flowrate to each raceway is 400–500 gpm, which results in an average water velocity of 0.04–0.05 ft/s through the raceways. Westers (1991) recommends a minimum velocity of 0.5 ft/s for effective solids transport through raceways. The raceways are brushed and flushed weekly for solids removal and quiescent zones and screens are also cleaned weekly.

Each raceway quiescent zone has a standpipe that is removed or a mud valve that is opened when raceways are cleaned. Quiescent zone cleaning flows from each bank of raceways are discharged to a 16-inch diameter line and flow by gravity to the raceway wastewater pump sump on the west side of the raceways. Each bank of raceways has its own 16-inch diameter cleaning flow line that discharges to the wastewater sump. Two vertical turbine pumps installed in the sump are used to pump cleaning flows through an 8-inch diameter line to the settling pond at the end of the peninsula. This settling pond discharges to the North Fork of the Clearwater River. A concrete channel at the discharge end of each bank of raceways collects bulk effluent from all of the raceways in the respective bank. Bulk effluent is discharged from each channel via a 30-inch diameter line; both 30-inch lines combine into a 36-inch diameter line that discharges directly to the North Fork adjacent to the fish ladder. The raceways also have a 16-inch diameter line that is used to stock smolts directly into the North Fork.

Operation and Maintenance

Dworshak NFH has a maintenance staff of eight personnel. Daily, monthly, and yearly schedules are followed to maintain systems and equipment on station in support of the hatchery's mission. A schedule of pumps used throughout the hatchery is presented in Table 4. All pumps utilize 480-volt, 3-phase power.

Pump Location	Pump Manufacturer	Flowrate (gpm)	Total Dynamic Head (ft)	Pump Motor Manufacturer	Pump Motor Size (HP)	RPM
Influent Treatment Sump	Peabody Floway	15,000	55	U.S. Motors	250	880
Influent Treatment Sump	Peabody Floway	15,000	55	U.S. Motors	250	880
Influent Treatment Sump	Peabody Floway	15,000	55	U.S. Motors	250	880
Influent Treatment Sump	Peabody Floway	15,000	55	U.S. Motors	250	880
Influent Treatment Sump	Ingersoll Rand	15,000	55	General Electric	250	900
Influent Treatment Sump	Ingersoll Rand	15,000	55	General Electric	250	900
Fire Maintenance Bldg.	Aurora Pump	100	120 psi	Marathon (Super-E)	15	3,493
Fire Maintenance Bldg.	Aurora Pump	100	120 psi	Marathon (Super-E)	15	3,493
Fire Maintenance Bldg.	Aurora Pump	500	120 psi	Marathon (Super-E)	40	3,540
Mechanical 1 Sump	Peabody Floway	750	84	General Electric	60	1,765
Mechanical 1 Sump	Peabody Floway	750	84	General Electric	60	1,765
Mechanical 1 Sump	Peabody Floway	750	84	General Electric	60	1,765
Mechanical 1 Sump	Goulds U.S. Pump	650	90	U.S. Motors	15	1,760
Mechanical 1 Sump	Goulds U.S. Pump	650	90	U.S. Motors	15	1,760
Mechanical 1 Boilers	Pacific Pump Co.	1,000	50	General Electric	15	1,750
Mechanical 1 Boilers	Pacific Pump Co.	1,000	50	General Electric	15	1,750
Mechanical 2 Sump	Peerless Pump Co.	1,475	260	U.S. Motors	125	1,760
Mechanical 2 Sump	Peerless Pump Co.	1,475	260	U.S. Motors	125	1,760
Mechanical 2 Sump	Peerless Pump Co.	1,475	260	U.S. Motors	125	1,760
Mechanical 2 Sump	Peerless Pump Co.	1,475	260	U.S. Motors	125	1,760
Mechanical 2 Boilers	Pacific Pump Co.	1,550	95	Baldor Electric Co. (Super-E)	50	1,775
Mechanical 2 Boilers	Pacific Pump Co.	1,550	95	Baldor Electric Co. (Super-E)	50	1,775
Mechanical 2 Boilers	Pacific Pump Co.	1,550	95	Baldor Electric Co. (Super-E)	50	1,775
Mechanical 2 Boilers	Pacific Pump Co.	1,550	95	Baldor Electric Co. (Super-E)	50	1,775
System I Reuse Sump	VertiLine Aurora Pump	5,000	72	Emerson Motor Technologies	125	1,750
System I Reuse Sump	VertiLine Aurora Pump	5,000	72	Emerson Motor Technologies	125	1,750
System I Reuse Sump	VertiLine Aurora Pump	5,000	72	Emerson Motor Technologies	125	1,750
System I Reuse Sump	VertiLine Aurora Pump	5,000	72	Emerson Motor Technologies	125	1,750
System I Solids	Yeomans Chicago Corp.	500	19	U.S. Motors	5	1,170
System I Solids	Yeomans Chicago Corp.	500	19	U.S. Motors	5	1,170
System I Digester Tanks	Hydromatic Pump	20	30	General Electric	7.5	1,750
System I Digester Tanks	Hydromatic Pump	20	30	General Electric	7.5	1,750
System II Channel	Aurora Pump	10,000	11.1	General Electric	40	880
System II Channel	Aurora Pump	10,000	11.1	General Electric	40	880
System II Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System II Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System II Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System II & III Solids	Weinman Pump	--	--	U.S. Motors	7.5	--
System III Channel	Aurora Pump	12,000	13.35	General Electric	50	880
System III Channel	Aurora Pump	12,000	13.35	General Electric	50	880
System III Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System III Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System III Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
System III Reuse Sump	Peerless Pump Co.	7,500	70	U.S. Motors	200	1,785
Raceway Manhole	Pacific Pump Co.	1,000	26	Reliance Electric	10	1,150
Raceway Manhole	Pacific Pump Co.	1,000	26	Reliance Electric	10	1,150
Drying bed supernatant	Little Giant Pump	42	10	--	0.4	--

Table 4. Summary of pumps at Dworshak NFH (all pumps operate on 480-volt, 3-phase power).

Biological Production

Steelhead, spring Chinook salmon, rainbow trout, and Coho salmon are currently raised at Dworshak NFH.

Steelhead

Dworshak NFH attempts to collect enough steelhead broodstock to have a 1:1 male:female pairing for spawning, but historical returns typically only allow the collection of enough broodstock to achieve a 1:1.2 ratio. Approximately 4,000–4,500 broodstock need to be collected each year to meet the ideal pairing ratio and meet the hatchery's goal to stock 2–2.2 million spring smolts. The fish ladder on station is operated each fall for the steelhead program to collect 500 early returning broodstock. Most years the ladder is open during the month of October, but it could be operational for shorter or longer periods depending on the year and the resulting number of returning broodstock; the ladder remains open for steelhead in the fall until 500 broodstock are collected. The ladder is opened again from mid-February through April to collect mid and late returning broodstock. Broodstock are kept in the holding ponds on station until they are spawned and they are never fed while on station. Spawning typically begins at the end of January and lasts through early May. Some of the early return males are injected with a hormone 10–14 days prior to spawning. Broodstock are spawned one day a week in the hatchery's spawning room, which is located across from the incubation room. The spawning process at Dworshak NFH is terminal; after spawning, spent steelhead broodstock are frozen and then transported to the local landfill or donated to the local food bank; all of the hormone-treated fish are sent to the landfill.

Steelhead adults are sampled for infectious hematopoietic necrosis (IHN), infectious pancreatic necrosis (IPN) and viral hemorahegic septicemia (VHS) viruses, bacterial kidney disease (BKD), furunculosis (*Aeromonas salmonicida*), enteric redmouth diseases (*Yersinia ruckeri*), whirling disease (*myxobolus cerebralis*), and ceratomyxa shasta during spawning. Eggs from adults testing positive for IHN are not discarded if they are kept at Dworshak NFH. Eggs that are sent to Clearwater Hatchery or Magic Valley Hatchery are never sourced from IHN-positive adults. Dworshak NFH currently provides 1.5 million green eggs to the IDFG for the Magic Valley Hatchery and 1.2 million eyed eggs for incubation at the Clearwater Hatchery. After spawning, eggs are water-hardened for 30 minutes in water with 75 mg/L iodophor buffered with sodium bicarbonate. Eggs at Dworshak NFH are incubated in the standard vertical tray incubators located in the incubation room for approximately 14 days until they reach the eye-up stage. Before the eye-up stage, eggs are treated with formalin three days per week to reduce fungus. The incubation room has a formalin dosing system that administers drip treatments of 1,667 mg/L formalin for 15-minute durations. All incubation stacks are treated simultaneously. The system is turned on manually, but runs on a timer that shuts the system down after 15 minutes.

After eye-up, the steelhead eggs are shocked, counted, and transferred into the hatching jars in the tanks in the nursery room or to other facilities. Densities are approximately 6,500–7,000 eggs per tray and 16,500–18,000 eggs per jar. Heated reservoir water from Mechanical Building 1 is used for egg incubation, and the water temperature is maintained at 54°F. The water supply flowrate to each incubator stack is 4–5 gpm. Each incubation jar/nursery tank is initially supplied with 5 gpm and the water supply is increased to 40 gpm after eggs hatch into the tanks. Eggs hatch out of the incubation jars into the nursery tanks approximately 24 days after spawning at a water temperature of 54°F. There are 128 tanks in the nursery room, but they do not provide enough space to accommodate the steelhead eggs and young fry from the last three spawning events. As a result, those eggs are returned to the incubation trays after they are counted at the eye-up stage and are moved into the nursery room tanks after some of the young fish are moved into outdoor Burrows ponds and space becomes available. Fry from the first spawning events are typically moved outside into the Burrows ponds starting at the end of May. Hatchery staff estimate another 32 nursery tanks are needed to accommodate all of the steelhead eggs and fry from the last spawning events.

Heated reservoir water from Mechanical Building 2 is used in the nursery room for steelhead from January through May when the reservoir water is below 54°F. Process piping allows for the use of heated water from Mechanical Building 1 in the A Bank of nursery tanks, but this operation is not typical. Before the hatchery was able to heat reservoir water for use in the incubation and nursery rooms, river water was used and the hatchery experienced severe IHN virus problems. The IHN virus is endemic to the river system and adults carrying the virus congregate around the hatchery's river intake structure, shedding the virus. Steelhead fry in the nursery room tanks are hand-fed eight times per day (from 6 AM until 3 PM) at 0.35% of their body weight, which is adjusted weekly. Feeding begins approximately 2–2.5 weeks after hatching. The nursery tanks are brushed and flushed on a daily basis at which time dead fry are also removed. Fry are not split into additional nursery tanks as they grow; the density index increases with growth and is approximately 0.7 when they are moved outside to the Burrows ponds.

Young steelhead are moved out of the nursery into outdoor Burrows ponds beginning at the end of May and continuing through August as cohorts mature. The river water that is used for the Burrows ponds outside is slightly colder than the water used in the nursery. Prior to being moved outdoors, young fish are tempered with water that is approximately 10°F colder overnight to reduce stress. Fish are passed through a tagging trailer where they are fin clipped and inventoried as they are moved outside. The tagging trailer has the capacity to clip approximately 50,000 fish per hour in an automatic process. Fish are transported to outdoor ponds in an oxygenated tank using a fork-lift. Some of the young fish are also marked with coded wire tags or PIT tags. Steelhead are stocked into the Burrows ponds outside at a density of 30,000 fish per pond and are not split as they grow. The resulting density index per pond is approximately 0.24 when they are stocked the next spring at 200 mm weighing 5–6 fish per pound (FPP). All of the Burrows ponds in Systems I, II, and III are used to raise steelhead, excluding two ponds in System III, which are used for rainbow trout.

Steelhead outside are hand-fed for several weeks after being moved from the nursery. They are transitioned to demand feeders when they weigh 25 FPP (18 grams), and the demand feeders are filled with feed as needed. Steelhead stocking occurs in mid-April and the stocking goal size for steelhead is 180–200 mm at release. Half of the steelhead smolts are released 35 miles above the hatchery in the South Fork of the Clearwater River and the other half are released directly into the Clearwater River from Dworshak NFH. The two stocking events take place about one week apart and each spans the entire week.

Ichthyopthirius and IHN are problems in the Burrows ponds. IHN is introduced into the Burrows ponds from native fish in the river above the hatchery intake. Outbreaks in the ponds are experienced and exacerbated if fish are stressed, such as when fish are not handled well when in the tagging trailer and being moved into the ponds. In past years the hatchery has experienced mortality rates as high as 25–30% or as low as 5%; an extra 10% are typically stocked into each pond to account for mortality. Water is typically heated for use in the reuse systems using the boilers in Mechanical Building 2 from December through March to increase fish growth. Water temperatures are maintained around 52°F during reuse system operation. Water temperatures of 54°F are optimal for growth, but hatchery staff indicate that more fish health problems are encountered at higher water temperatures. When not operated in water reuse configuration, bath formalin treatments are administered to individual ponds as needed to treat for parasites at 167 mg/L formalin. The capacity to treat individual ponds during reuse does not exist. Prior to starting the reuse systems, all ponds are treated with a prophylactic formalin bath of 167mg/L formalin. Ponds are treated twice a week during the first four weeks of reuse system operation with 50 mg/L flow-through formalin treatments for 12-hour durations. Depending on the incidence of *ichthyopthirius* and other parasites, these twice-a-week formalin treatments may continue the entire time systems are operating in water reuse.

Sodium chloride (NaCl) and potassium chloride (KCl) are added directly to culture water when the reuse systems are in operation. The addition of these salts is presumably the result of research conducted at the hatchery in the late 1970s presented by Bradley (1984). Results from this research indicated a decrease in gill swelling and fish mortality with the addition of NaCl and KCl. Hatchery staff report the addition of minerals facilitates ion exchange on gills and reduces ammonia uptake. Enough NaCl and KCl are added to systems to reach target chloride concentrations of 45 mg/L, while maintaining a 2.5 to 1 ratio of sodium to potassium. Levels of ammonia, sodium, and potassium are measured in the reuse systems 2–3 times per week during operation of the dosing systems. Chloride levels are calculated based on sodium and potassium measurements. Potassium chloride is listed by the FDA as a low priority drug used as an osmoregulation aid; recommended dosages are as needed to increase the chloride ion concentration to 10–2,000 mg/L. Sodium chloride is also listed as a low priority drug by the FDA used for osmoregulation and also relieves stress and prevents shock when used as a 0.5–1% concentration. The addition of NaCl and KCl softens fish culture water, which is already low at approximately 12 mg/L $CaCO_3$. Approximately $30,000 per year is spent on minerals, and the need for their addition should be reconsidered under current hatchery operational scenarios.

Steelhead from the first spawning events do not typically need heated water in the outside ponds because they can achieve the desired growth over the longer growth period; whereas fish from later spawning events require heated water in order to grow to the target stocking size. In past years, the older fish hatched from the first spawning events were stocked into the Burrows ponds outside beginning in System I and fish from the last spawning events were stocked into System III ponds. Fish in System III ponds experience extensive health and disease problems when the reuse system is operated, which is largely attributable to solids and subsequent pathogen accumulation within the system. Beginning in 2006–2007, steelhead from the first spawning events have been stocked into System III ponds and the ponds have not been operated in reuse, yielding better growth and decreased mortality.

Spring Chinook Salmon

The Dworshak NFH fish ladder is operated from June through August to collect returning spring Chinook salmon broodstock. Broodstock are also collected during this time in fish traps near Kooskia NFH. Any adults that are collected in excess of spawning needs, or fish other than Chinook adults, are stocked into nearby rivers for recreational fishing. Broodstock are kept in the holding ponds on station until they are spawned beginning in August. Broodstock collected in traps near Kooskia NFH are held in one pond and broodstock returning to Dworshak NFH are held in the remaining ponds.

Adults receive prophylactic formalin treatments to control fungus and incoming females receive erythromycin injections at 20 mg/kg body weight approximately 21 days prior to spawning to reduce vertical transmission of bacterial kidney disease (BKD). Spawning occurs once a week through mid-September. Chinook broodstock are treated with tricaine methanesulfonate (MS-222) and Pro-Polyaqua during spawning and are therefore not suitable for consumption. Spent broodstock are typically frozen and then transported to the local landfill or given to Washington State University's grizzly bear research program and other bear research programs in Idaho. Female broodstock are tested for BKD during spawning and eggs from broodstock with moderate to high levels of bacteria are discarded.

After spawning, eggs are water-hardened for 30 minutes in water with 75 mg/L iodophor buffered with sodium bicarbonate. Eggs are then incubated in the vertical tray incubator stacks located in the incubation room at densities of 3,500–4,000 eggs per tray, where they remain from August through April. Eggs from broodstock that are caught in traps at Kooskia NFH are returned to that hatchery after reaching the eye-up stage. The incubation room chiller is currently used to cool water to 37–38°F for incubation, retarding egg development by approximately 2–3 months. Prior to this growth manipulation, the spring Chinook salmon would be 6–8 fish per pound when stocked in the spring, which led to high loading densities in the outdoor raceways and increased disease problems. Using chilled water for incubation slows growth, eliminating the need to fast the fish to reduce growth, and results in lower loading densities and fewer disease problems. Spring Chinook salmon smolts are currently 18–20 fish to the pound when stocked in the spring

Drip treatments of 1,667 mg/L formalin are administered to the incubation stacks two days per week for 15-minute durations from August through December until eggs eye up. In April, spring Chinook fry are ponded directly into the flow-through raceways outside. Direct ponding minimizes holding stress and subsequent disease problems. River water is used in the outdoor raceways and is approximately 41°F when fish are first stocked outside. Chinook fry are stocked into ten raceways at 100,000 fish per raceway and are initially crowded into a third of the raceways. Fry begin feeding shortly after they are ponded and are hand-fed 3–4 times per day. The outdoor raceways are currently brushed weekly and cleaning flows are pumped to the settling pond at the end of the peninsula and then discharged to the North Fork of the Clearwater River. Bulk raceway effluent is discharged directly to the North Fork.

The young Chinook salmon are fin-clipped or marked with coded wire tags in August, at which time they are also split into the remaining raceways, resulting in a loading of approximately 30,000–35,000 fish per raceway. In late March to early April, the Chinook smolts are stocked directly into the North Fork of the Clearwater River from the raceways via a 16-inch diameter planting line. The release of Chinook smolts is coordinated with the operation of the dam. Approximately 1–1.04 million smolts weighing 18–20 fish to the pound are released each spring. The density index per raceway is approximately 0.24 at the end of the growth cycle when Chinook are stocked in the spring; the goal is to maintain the density index below 0.30. There is approximately a two-week time period when the Chinook raceways are empty before the next year's cohort is brought outside.

Rainbow Trout

Dworshak NFH raises approximately 15,000 rainbow trout for Open House and National Fish Day events. Rainbow trout in excess of these event needs are stocked into landlocked tribal and public lakes in northern Idaho. Eyed eggs are received from Ennis NFH (Ennis, MT), which is a rainbow trout broodstock hatchery. Eggs are incubated in vertical trays from January through March at water temperatures of 48–50°F. No formalin treatments are required since the eggs have reached the eye-up stage when they are received on station. Rainbow trout fry are ponded in the four 6-foot diameter green tanks that are located in the incubation room and remain there until the end of May. They are then stocked outside into two of the Burrows ponds in System III and remain on station for approximately one year at which time they are stocked, weighing approximately one pound. Rainbow trout fry begin feeding in March when they are inside. Feeding begins at 3% BW per day and decreases to 2% BW per day after they are moved outside. Approximately 150–200 pounds of food is fed to rainbow trout inside and approximately 16,000 pounds is fed outside each year.

Coho Salmon

The USFWS currently cooperates with the Nez Perce Tribe as co-managers of Dworshak NFH to raise 280,000 Coho salmon smolts each year. The USFWS provides rearing space on station for the Coho program and members of the tribe care for the fish. The tribe currently collects adult Coho salmon broodstock that return to spawn at Dworshak NFH from the fish ladder on station, as well as broodstock returning to spawn at a number of other locations. All of the Coho broodstock collected are kept in the holding ponds at Dworshak NFH until October–November when they are spawned. They are not fed while on station.

Eggs are incubated in vertical trays in the incubation room from the end of October through December–January. Eight double stacks of incubators are typically used to incubate Coho salmon eggs. Drip treatments of formalin at 1,667 mg/L are administered to eggs twice a week for 15-minute durations to control fungus on eggs prior to eye-up. Approximately 4–5 gpm of ambient reservoir water is supplied to each incubation stack. Water temperature during this time varies from 41–54°F depending on which reservoir intake is being used. Eggs remain in the incubation trays until they hatch. Coho fry are raised in the nursery building from January through March, occupying 16 tanks. Approximately 40 gpm of reservoir water is supplied to each nursery tank. Coho are stocked outside in the spring into one of the five adult holding ponds that have been converted to raceways; the five holding ponds have been converted to ten raceways. They are raised in one of the converted raceways for about a year at which time the pre-smolts are transferred to Kooskia NFH and raised for another 2–3 months or 3–4 weeks and then released in late April or May. All feeding and cleaning is completed by members of the Nez Perce Tribe.

Production Schedule

Biological production plans for Dworshak NFH are summarized in Tables 5–7. Table 5 includes monthly schedules for feed, flow required, and total biomass on a facility-basis, while Tables 6–7 contain the same bioplan information for the individual steelhead and spring Chinook salmon programs. Biological production plans were prepared in cooperation with Dworshak NFH staff in the summer of 2007 and represent the most current conditions for feed, flow, and biomass levels.

	Feed Fed					Water Flow						Biomass				
Month	**Holding/ Receiving (lb)**	**Nursery Building (lb)**	**Raceways (lb)**	**Burrows Ponds (lb)**	**Total (lb)**	**Holding/ Receiving (gpm)**	**Incubation Room (gpm)**	**Nursery Building (gpm)**	**Raceways (gpm)**	**Burrows Ponds (gpm)**	**Total (gpm)**	**Holding/ Receiving[1] (lb)**	**Nursery Building (lb)**	**Raceways (lb)**	**Burrows Ponds (lb)**	**Total (lb)**
January	0	0	9,276	46,297	55,573	4,200	135	0	12,000	50,400	66,735	6,000	0	40,869	247,998	294,867
February	0	0	7,618	53,966	61,584	6,300	135	640	12,000	50,400	69,475	4,200	360	46,873	290,245	341,678
March	0	604	11,364	57,921	69,889	8,400	165	2,560	12,000	50,400	73,525	6,000	1,360	54,388	338,557	400,305
April	0	2,202	338	5,470	8,010	8,400	165	5,120	3,000	50,400	67,085	4,200	4,330	1,213	345,855	355,598
May	0	5,365	1,174	233	6,771	16,800	60	5,120	3,000	6,000	30,980	2,500	5,330	2,437	4,628	14,895
June	0	7,373	2,563	3,787	13,723	8,400	50	5,120	3,000	9,600	26,170	5,000	13,000	5,053	9,598	32,651
July	0	8,916	2,485	8,826	20,226	8,400	0	5,120	3,000	35,400	51,920	24,000	14,070	8,229	29,225	75,524
August	0	3,825	2,842	23,308	29,974	8,400	270	5,120	12,000	50,400	76,190	27,000	15,000	10,329	64,581	116,910
September	0	0	6,437	39,843	46,280	8,400	270	0	12,000	50,400	71,070	7,500	0	16,248	101,587	125,334
October	0	0	6,209	51,924	58,132	4,200	200	0	12,000	50,400	66,800	6,000	0	20,716	146,519	173,235
November	0	0	9,723	35,871	45,594	4,200	75	0	12,000	50,400	66,675	6,000	0	28,442	167,401	201,843
December	0	0	9,427	40,677	50,104	4,200	75	0	12,000	50,400	66,675	6,000	0	34,477	201,912	242,389

[1]Assumes returning steelhead broodstock weigh 12 pounds and returning spring Chinook salmon broodstock weigh 15 pounds.

Table 5. Facility-based biological production plan for Dworshak NFH (average data from FY2005–2007 records provided by hatchery staff).

Month	Feed Fed						Water Flow							Biomass					
	Holding/ Receiving (lb)	**Nursery Building (lb)**	**System I (lb)**	**System II (lb)**	**System III (lb)**	**Total (lb)**	**Holding/ Receiving (gpm)**	**Incubation Room (gpm)**	**Nursery Building (gpm)**	**System I (gpm)**	**System II (gpm)**	**System III (gpm)**	**Total (gpm)**	**Holding/ Receiving[1] (lb)**	**Nursery Building (lb)**	**System I (lb)**	**System II (lb)**	**System III (lb)**	**Total (lb)**
January	0	0	14,539	17,388	14,371	46,297	4,200	60	0	15,000	15,000	20,400	54,660	6,000	0	79,943	81,632	86,423	253,998
February	0	0	20,683	23,935	9,349	53,966	6,300	60	640	15,000	15,000	20,400	57,400	4,200	360	96,123	102,304	91,819	294,805
March	0	604	17,017	17,498	23,406	58,525	8,400	90	2,560	15,000	15,000	20,400	61,450	6,000	1,360	110,957	116,891	110,709	345,917
April	0	2,202	1,568	1,642	2,260	7,672	8,400	90	5,120	15,000	15,000	20,400	64,010	4,200	4,330	112,645	118,725	114,486	354,385
May	0	5,365	0	0	233	5,598	8,400	60	5,120	0	0	6,000	19,580	0	5,330	0	0	4,628	9,958
June	0	7,373	0	0	3,787	11,160	0	50	5,120	0	0	9,600	14,770	0	13,000	0	0	9,598	22,598
July	0	8,916	46	435	8,345	17,741	0	0	5,120	0	15,000	20,400	40,520	0	14,070	334	5,174	23,718	43,295
August	0	3,825	1,843	5,801	15,664	27,133	0	0	5,120	15,000	15,000	20,400	55,520	0	15,000	12,556	16,707	35,319	79,581
September	0	0	7,151	10,579	22,114	39,843	0	0	0	15,000	15,000	20,400	50,400	0	0	19,911	27,709	53,968	101,587
October	0	0	10,849	17,985	23,090	51,924	4,200	0	0	15,000	15,000	20,400	54,600	6,000	0	30,714	44,699	71,106	152,519
November	0	0	12,412	9,968	13,491	35,871	4,200	0	0	15,000	15,000	20,400	54,600	6,000	0	39,020	50,226	78,155	173,401
December	0	0	14,856	13,221	12,600	40,677	4,200	0	0	15,000	15,000	20,400	54,600	6,000	0	53,090	62,040	86,782	207,912

[1]Assumes returning steelhead broodstock weigh 12 pounds.

Table 6. Monthly biological production plan for the steelhead program at Dworshak NFH (average data from FY2005–2007 records provided by hatchery staff).

Month	Feed Fed				Water Flow				Biomass			
	Holding/ Receiving (lb)	Nursery Building (lb)	Raceways (lb)	Total (lb)	Holding/ Receiving (gpm)	Incubation Room[1] (gpm)	Raceways (gpm)	Total (gpm)	Holding/ Receiving[2] (lb)	Nursery Building (lb)	Raceways (lb)	Total (lb)
January	0	0	9,276	9,276	0	75	12,000	12,075	0	0	40,869	42,000
February	0	0	7,618	7,618	0	75	12,000	12,075	0	0	46,873	47,000
March	0	0	11,364	11,364	0	75	12,000	12,075	0	0	54,388	65,000
April	0	0	338	338	0	75	3,000	3,075	0	0	1,213	1,300
May	0	0	1,174	1,174	8,400	0	3,000	11,400	2,500	0	2,437	5,000
June	0	0	2,563	2,563	8,400	0	3,000	11,400	5,000	0	5,053	10,200
July	0	0	2,485	2,485	8,400	0	3,000	11,400	24,000	0	8,229	31,200
August	0	0	2,842	2,842	8,400	270	12,000	20,670	27,000	0	10,329	37,000
September	0	0	6,437	6,437	8,400	270	12,000	20,670	7,500	0	16,248	22,500
October	0	0	6,209	6,209	0	200	12,000	12,200	0	0	20,716	22,000
November	0	0	9,723	9,723	0	75	12,000	12,075	0	0	28,442	28,000
December	0	0	9,427	9,427	0	75	12,000	12,075	0	0	34,477	34,000

[1]Water used for egg incubation only; fry are ponded in outdoor raceways.
[2]Assumes returning spring Chinook salmon broodstock weigh 15 pounds.

Table 7. Monthly biological production plan for the spring Chinook salmon program at Dworshak NFH (average data from FY2005–2007 records provided by hatchery staff).

Stocking Schedule

Dworshak NFH supports two major fish mitigation programs for the Pacific Northwest, producing 2–2.2 million steelhead smolts and 1–1.04 million spring Chinook salmon smolts. Table 8 summarizes the average number and biomass of fish from these programs that are distributed from Dworshak NFH.

Species	Stocking Location	Agency	Number	Weight (lb)
Steelhead Smolts	South Fork of the Clearwater River	USFWS	1.0–1.25 million	145,000–180,000
Steelhead Smolts	Clearwater River	USFWS	1.0–1.25 million	145,000–180,000
Spring Chinook Salmon Smolts	North Fork of the Clearwater River	USFWS	1–1.04 million	55,000–70,000
Rainbow Trout	Dworshak Reservoir	USFWS	15,000	15,000
Coho Salmon Smolts	Clearwater River	Nez Perce Tribe	280,000	14,450

Table 8. Average fish distribution from Dworshak NFH in 2006.

Feed Fed

Young fish on station are hand-fed and demand feeders are used in Burrows ponds and raceways for older fish. None of the broodstock that are collected at the hatchery and maintained in the holding ponds are fed. Fish on station receive feed manufactured by Skretting. Approximately $240,000 per year is spent on fish feed for steelhead and rainbow trout and $45,000 is spent for Chinook feed. Steelhead in the Burrows ponds are fed food that is treated with florfenicol to treat coldwater disease when needed.

Fish Health

Pathogens of Concern

IHN virus is the primary disease concern for steelhead and BKD is the primary disease concern for spring Chinook salmon raised at Dworshak NFH. The preventative measures the hatchery has employed in recent years during spawning of Chinook broodstock has reduced many BKD concerns pertaining to fish on station. During the latter part of rearing, samples are collected monthly from ten Chinook smolts and ten steelhead smolts and tested for BKD and IHN, respectively. Spring Chinook salmon in raceways experience occasional problems with external parasites, which are controlled with formalin. Steelhead in the Burrows ponds sometimes have problems with IHN, coldwater disease, and *ichthyopthirius*. IHN is presumably introduced into the Burrows ponds with the river water supply as fish spawning in the river above the hatchery intake shed the virus. Outbreaks are experienced and exacerbated if fish are stressed. Coldwater disease is only seen in conjunction with IHN in steelhead. Steelhead are fed florfenicol-treated feed as necessary for coldwater disease and formalin is used to treat external parasites. Water temperatures in the Burrows ponds reuse systems are maintained below 54°F to reduce *ichthyopthirius* problems. Rainbow and steelhead sometimes have problems with external parasites such as trichodina and costia, and Coho salmon are also susceptible to coldwater disease, which reportedly can be in the water supply and is also vertically transmitted.

Past History of Disease

IHN-carrying adult steelhead congregate in the North Fork of the Clearwater River near the hatchery intake, shedding the virus. Prior to the installation of the reservoir line and piping modifications that allow the use of the reservoir water in the nursery building, the hatchery experienced significant fry mortalities in the nursery room when river water was used. Since then, IHN has only been a problem in the nursery building on two occasions in the early 1990s. Steelhead mortalities from IHN occur in the Burrows ponds, particularly during early summer.

Disease Surveillance

Tissue and ovarian samples are collected from broodstock to monitor for reportable pathogens and diseases. Tissues from sampled broodstock are tested for furunculosis (*Aeromonas salmonicida*), enteric redmouth disease (*Yersinia ruckeri*), whirling disease (*myxobolus cerebralis*), and ceratomyxa shasta. Disease testing also includes IHN, infectious pancreatic necrosis virus (IPNV), and viral hemorrhagic septicemia (VHS) screening. Testing includes 150 ovarian fluid samples and 60 tissue samples from broodstock for each program. Smolts from all programs are also tested for reportable pathogens and diseases before they are released from the hatchery. Samples are collected from 60 smolts from each program approximately 3–4 weeks before their release. All sample collection methods and testing procedures are performed in accordance with the guidelines from the American Fisheries Society/USFWS Inspection Manual.

Because the IHN virus is endemic to the river basin, all steelhead broodstock are sampled for IHN during spawning. Eggs that test positive for IHN are kept on station at Dworshak NFH, but are not transferred to other hatcheries. All female spring Chinook salmon broodstock receive erythromycin injections of 20 mg/kg body weight 21 days prior to spawning to reduce vertical transmission of BKD. All female Chinook broodstock are tested for BKD using an enzyme-linked immunosorbent assay (ELISA) when they are spawned. The ELISA test detects the level of *Renibacterium salmoninarum* in the fish, the bacteria that cause BKD. ELISA readings between 0.096-0.199 are considered low risk for BKD, 0.2-0.99 are medium risk, and 1 and over are high risk. At Dworshak NFH, eggs from females with ELISA readings above 0.250 are discarded.

Use of Therapeutants

Formalin is typically used in the incubation room to treat fungus on eggs prior to eye-up. Steelhead eggs are treated with formalin three days per week from January through June. Chinook eggs are treated twice a week from August through December. Coho eggs are treated twice a week until they eye-up. Fungus is not a concern for rainbow trout eggs and they do not receive formalin treatments. Formalin is administered to incubation stacks as drip treatments at formalin concentrations of 1,667 mg/L for 15-minute durations. A total of 170 gallons of formalin was used in the incubation room during the 2006–2007 incubation season. The formalin use during this time for individual programs was 46 gallons for steelhead egg incubation, 110 gallons for spring Chinook salmon egg incubation, and 14 gallons for Coho salmon egg incubation.

Formalin is used in the Burrows ponds to treat *ichthyopthirius* and coldwater disease. When ponds are not being operated in reuse configuration, bath treatments of formalin are administered to individual ponds as needed to control parasites at 167 mg/L formalin. Prophylactic formalin baths are administered to all ponds prior to the start of the reuse systems. Ponds are treated with 50 mg/L formalin in flow-through for 12-hour durations twice a week after the reuse systems begin operating and are continued for a minimum of four weeks. During 2005–2006, 4,580 gallons of formalin was used to treat Burrows ponds in Systems II and III when they were operated in reuse. In 2006–2007, System I was operated in reuse instead of System III, and the combined formalin usage to treat ponds in Systems I and II was 2,700 gallons, a 47% reduction from the year before. Formalin use in the holding ponds was 2,700 gallons in FY 2005–2006. In 2003, $25,000 was spent on chemicals and drugs for the steelhead and rainbow trout programs at Dworshak NFH and $6,000 was spent on drugs and chemicals for the Chinook program.

Formalin treatment of Spring Chinook salmon in raceways is rare, but sometimes required when parasites are problematic. When this occurs, a one-hour formalin bath of 167 mg/L is administered in each raceway with 100 pounds of salt. Similar treatments would be administered to treat coho salmon in the converted holding pond raceways; however they are not typically treated.

Biosecurity Protocols

Quarantine Periods and Egg Disinfection

Adult broodstock for the steelhead, spring Chinook salmon, and Coho salmon programs are captured from the fish ladder at Dworshak NFH and kept in the holding ponds on station until they are spawned. Eggs from steelhead broodstock that test positive for IHN are not transferred offsite. Eggs from spring Chinook salmon females with moderate to high levels of BKD-causing bacteria in their kidneys are discarded. All eggs from broodstock spawned at Dworshak NFH are water-hardened in the incubation trays for 30 minutes in water with 75 mg/L iodophore that is buffered with sodium bicarbonate.

Equipment Disinfection

Footbaths containing Virkon®S are located at the entrances to the nursery and incubation rooms. Groups of tanks and incubation stacks in the nursery building have separate nets. Each outdoor system also has its own set of nets and brushes, which are not shared among systems. Fish hauling distribution truck tanks are disinfected between uses by adding one gallon of chlorine to a tank that is filled with hatchery water and allowing it to sit for 2–3 days. The tank is then emptied and flushed with clean water. The outside of fish hauling trucks are not disinfected.

The fish health unit has a biosecurity protocol that it follows when collecting fish samples and testing water quality throughout the hatchery. However, there is currently no biosecurity protocol for the hatchery as a whole for normal operations.

Fish Culture Area Disinfection

Raceways and holding ponds are not disinfected most years due to time constraints of the biological production schedules. Nursery tanks are disinfected between cohorts with a 200 mg/L chlorine bath. Following a 30-minute retention time, the chlorinated water is discharged to the nursery system clarifying basins. Sodium thiosulfate is used to neutralize chlorine in the nursery tanks. Incubation stacks and jars are cleaned with Simple Green, disinfected with iodine, and then allowed to air-dry between uses.

Burrows ponds and reuse systems are disinfected with chlorine every May after fish are stocked. Burrows ponds are filled with river water from the main aeration tower and chlorine is added to the ponds to achieve a concentration of 200 mg/L. The amount of chlorine in the ponds is measured to ensure the correct amount is added, and all three systems are disinfected simultaneously. After chlorine is added to the ponds, the reuse systems are turned on and chlorinated water is recirculated through the treatment equipment, sumps, and ponds for approximately four days. After four days, 10% of the flow is discharged to the river through the system overflows and makeup river water is added to the systems, gradually flushing the chlorinated water from the systems. Systems are flushed for several days and then the Burrows ponds are emptied, refilled with river water from the main aeration tower, and flushed directly to the Clearwater River through the hatchery's main outlet (outlet #011). After all of the ponds are flushed, they are filled with river water from the main aeration tower and ready for stocking. The chlorine concentration in the ponds is tested prior to stocking and ponds are flushed again if needed. Chlorine is not measured in effluent that is discharged from the ponds during flushing.

Vector Mitigation and Culture Units Covering

The main aeration tower is open to the environment, but hatchery staff do not typically observe ducks and other birds around the tower. Algae and small plants grow in the packed columns and around the aeration tower sump walls, and leaves float into the sump. The System I clarifying basins and Systems II and III biofilter basins are also open to the environment. All reuse pump sumps are fully enclosed and the three reuse system aeration tower sumps are covered with grating. The structures that cover the outdoor fish culture areas prevent birds from entering those areas, but do not prevent mammal predation.

Effluents

Effluent Quality

Discharge Permit

Discharge permits in the state of Idaho are issued through the U.S. Environmental Protection Agency (EPA). Dworshak NFH currently operates under discharge Permit #IDG131003, within the National Pollutant Discharge Elimination System (NPDES), General Permit #IDG131000 for Cold Water Aquaculture Facilities in Idaho without wasteload allocations. The facility submitted a Notice of Intent to discharge under the new permit in December 2007. The permit requires the facility to submit quarterly Discharge Monitoring Reports (DMRs) for total suspended solids, total ammonia, total phosphorous, pH, temperature, and flow. In receiving waters both above and below the facility ammonia, pH, and temperature are monitored quarterly. If chelated copper compounds or copper sulfate are used at the facility, effluent must be monitored for hardness and total recoverable copper. The permit also requires the facility to write an Annual Report and maintain Quality Assurance (QA) and Best Management Practice (BMP) plans.

Contact for NPDES Permitting

U.S. Environmental Protection Agency Region 10
NPDES Permits Unit
1200 Sixth Avenue, OWW-130
Seattle, Washington 98101
206–553–0523

Idaho Department of Environmental Quality
Regional Manager – Engineering
Lewiston Regional Office
1118 F St.
Lewiston, Idaho 83501
208–799–4370

The Idaho Code of Statutes, Title 39, Chapter 1 (39-118) requires that all plans for the construction or modification of aquaculture wastewater treatment facilities in the state be submitted to and approved by the director of the Idaho Department of Environmental Quality (IDEQ) prior to construction or modification. The director reviews the plans and project specifications for conformance to industry standard practices and best management guidelines and grants approval or disapproval of the project. The IDEQ must also be notified when the project is complete so that a representative from the IDEQ can conduct an onsite inspection of the completed project to ensure compliance with the approved plans and specifications.

The IDEQ allows land application of aquaculture wastes, including solids and liquids removed during quiescent zone cleaning, slurries removed from settling ponds, and dried solids removed from settling ponds and drying beds. The IDEQ does not require a permit for land application of the aquaculture wastes, but requires the development of a disposal plan that conforms to guidance outlined in IDAPA 16, Title 01, Chapter 2, Section 650 and adherence to that plan.

Wastewater Treatment

Dworshak NFH currently has a total of 20 discharges from the hatchery, although many of them are storm drains or overflows that do not come into contact with fish rearing environments or do not discharge on a continuous basis. The hatchery has seven outfalls to the North Fork of the Clearwater River and 13 outfalls to the main stem of the Clearwater River. Effluent that is discharged from 13 of the locations comes into contact with fish rearing environments on a regular basis for continuous periods of time; more than 30 consecutive days. A process flow diagram including effluent collection, treatment processes, and discharge outlets at Dworshak NFH is provided in Figure 26. The locations of treatment processes are indicated in the Figure 12 hatchery layout.

Effluent from the nursery room is always treated with the two clarifying basins (#7 and #8) located adjacent to the clarifying basins for System I. Effluent from the incubation room is discharged directly to the river through a series of storm drains and is not screened to prevent unintentional discharge of eggs from the hatchery. Bulk effluent from System I Burrows ponds is only directed to the system's clarifying basins for treatment when operated in reuse because the 24-inch diameter drain line from the clarified basin effluent discharge channel to the North Fork River cannot accommodate the entire system flow. System I Burrows pond bulk effluent is discharged directly to the Clearwater River when not operated in reuse; however cleaning pond flows are separated from the rest of System I effluent and directed to the System I clarifying basins. Settled solids from the System I clarifiers are stored in two aerobic digester tanks. Supernatant from the digester tanks can be discharged to the North Fork of the Clearwater River, but current operational practices do not include discharging anything from these tanks directly to the river.

When not operating in water reuse, bulk pond effluent from Systems II and III is discharged directly to the Clearwater and North Fork Rivers, with no treatment. Cleaning flows from ponds in System II are separated from the bulk effluent and directed to the reuse system biofilter basins. Cleaning flows from ponds in System III can not be separated from the rest of System III pond effluent, but the entire flow is directed to the System III biofilter basins when ponds are being cleaned. When in use, solids are scraped from the biofilter basins in reuse Systems II and III daily and pumped to a wastewater treatment aeration basin on the west side of the biofilter basins.

The wastewater aeration basin has a paddlewheel aerator that is operated when solids are pumped into the basin. The concrete basin is approximately 75 feet long and 20 feet wide. The bottom of the basin is sloped, resulting in a depth that varies from 14.25 to 13 feet. This wastewater basin has an approximate storage capacity of 125,000 gallons operated with a storage depth of 11 feet. The basin has a high level alarm to provide notification of an emergency condition through the main hatchery alarm system. Solids are pumped from the wastewater aeration basin once a year to two drying beds, cell #1 and cell #2. The drying beds are not lined; a portion of the water seeps through the ground and the supernatant is pumped to the adjoining settling pond. The drying beds are also being used for solids collected in the System I clarifying basins and stored in the system's aerobic digester tanks. Solids are removed from drying beds when required and either applied to agricultural land or sent to the landfill (Figure 25).

Figure 25. Solids removal from drying beds for fertilizer use.

A settling pond is located adjacent to the two drying beds at the tip of the peninsula between the North Fork and the Clearwater Rivers. The settling pond receives the quiescent zone cleaning flow from Chinook raceways, which is collected in a sump and pumped to the settling pond. The settling pond also receives pumped supernatant from the adjacent drying beds when they are in use. The settling pond is approximately four feet deep and has an effective surface area of 6,836 ft^2. The settling pond has a 10-inch diameter discharge line to the North Fork.

Mortality Collection and Disposal

Everyday mortalities are placed in the freezer and are sent to the local landfill as needed. All spawning events at Dworshak NFH are terminal and broodstock must be disposed of. Early-returning steelhead males that are injected with hormones to stimulate spawning are disposed of in the local landfill. Other steelhead broodstock are donated to a local food bank when possible. Spent Chinook broodstock are sent to the landfill because they are treated with MS-222 during spawning and are not suitable for consumption. Spent broodstock are also sometimes given to Washington State University's grizzly bear research program and other bear research programs in Idaho.

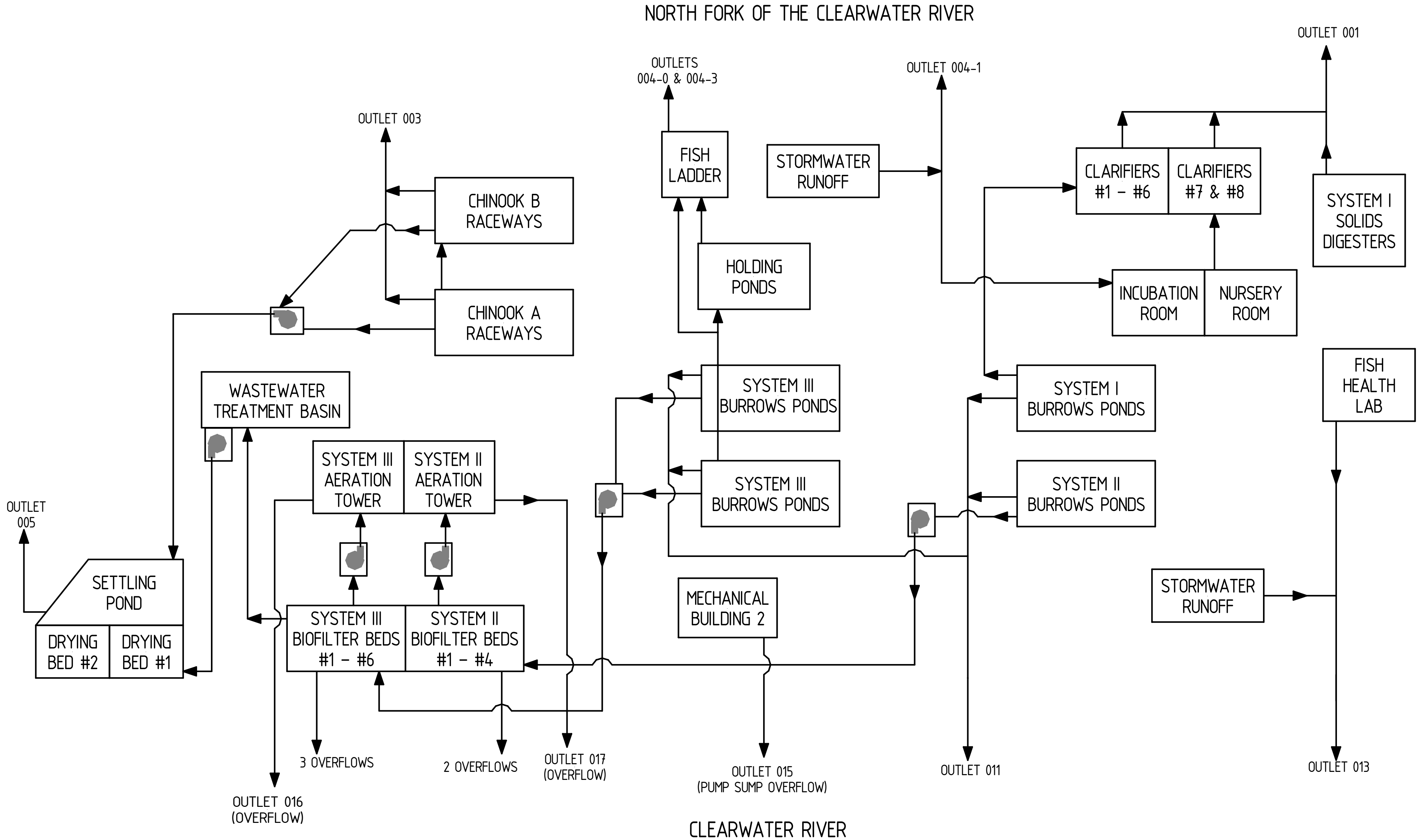


Figure 26. Effluent process flow diagram of fish culture facilities at Dworshak NFH.

IDENTIFIED NEEDS AND RECOMMENDATIONS

1. BEST MANAGEMENT PRACTICES TO IMPROVE REUSE SYSTEM WATER QUALITY AND MEET DISCHARGE PERMIT LIMITATIONS

DESCRIPTION

Dworshak NFH currently discharges the majority of hatchery effluent directly to either the North Fork of the Clearwater River or the Clearwater River with minimal or no effluent treatment. Nursery tank effluent is always treated in one of two full-flow clarifying basins. When not operated in reuse, effluent from ponds in Systems I and II is discharged directly to the Clearwater River with no treatment and pond effluent in System III is discharged directly to the Clearwater or North Fork Rivers. System I Burrows pond effluent is only treated in the system's clarifying basins during water reuse operation because the 24-inch diameter discharge line from the clarified effluent basin channel is not large enough to accommodate the entire system flowrate of 15,000 gpm. Bulk effluent from the Chinook raceways is discharged directly to the North Fork, while quiescent zone cleaning flows undergo treatment in the settling pond at the tip of the peninsula before discharge to the North Fork. This settling pond was originally constructed to treat backwash flows from sand filters in Mechanical Building 2, but was modified to treat raceway quiescent zone cleaning flows when the raceways were constructed in the 1980s and the sand filters were no longer in use. Effluent from the holding ponds, including the ten converted Coho raceways is discharged directly to the North Fork of the Clearwater River without treatment.

Two of the three Burrows ponds systems are typically operated in water reuse configuration for three months a year in order to increase water temperature and achieve faster fish growth in these systems. Water is reused within individual systems to avoid wasting heat, which is added to the systems with the makeup water. Fish typically experience poor health during the time the reuse systems are being operated, particularly fish in Systems II and III. System III is no longer operated in reuse configuration due to the extensive decline in fish health during reuse operation.

As explained in the existing conditions, Systems II and III have floating-bed and submerged-bed biofilters and have no infrastructure for removal of waste solids prior to these biofilters. As such, biofilters in both systems experience heavy solids accumulation, and these waste solids can not be fully removed from the systems. The accumulation of solids in the biofilter basins results in poor system water quality and also provides a reservoir for pathogens. Water reuse treatment infrastructure in System I consists of clarifying basins prior to system biofilters. The clarifying basins allow the removal of a portion of waste solids from the reuse water prior to biofilters, resulting in better solids control compared to other systems. Solids filtration of Burrows pond effluent prior to reuse within fish rearing systems is imperative for improving fish health on station and enabling the hatchery to meet production goals. Solids filtration of fish culture effluent is also an important best management practice and will ensure NPDES permit compliance when the hatchery is not operating in water reuse configuration.

RECOMMENDATION

A comprehensive effluent treatment regime should be implemented for fish culture systems throughout the facility. The effluent treatment regime should consist of microscreen filtration of hatchery effluent combined with a program to manage the solids removed. Microscreen filters sieve and strain solids from the water they are treating, and filtration is expected to remove 35–50% of the total suspended solids from the effluent process flow. Microscreen filtration removal efficiencies are dependent on the size and concentration of waste solids in the water undergoing treatment.

As water enters the interior of a microscreen filter, it is passed through screens with small openings; solids larger than the screen openings are retained on the screens. As particulate matter is screened from the effluent and collects on the filter media, the headloss across the filter increases and the water level within the microscreen filter rises, triggering an automatic high-pressure water (80–100 psi) rinse of the filter media. Solids are rinsed from the filter media into a backwash collection trough as the filter rotates, which takes approximately 30 seconds. The frequency of microscreen filter backwash cycles is dependent on the amount of particulate matter screened from the effluent, which is affected by the biomass of fish on station and their feeding rate. As the microscreen filters backwash, the backwash waste stream will be discharged to a storage location, as identified below for each system. The operation of a microscreen drum filter is illustrated in Figure 27; arrows indicate the treated water flow and filterable solids paths.

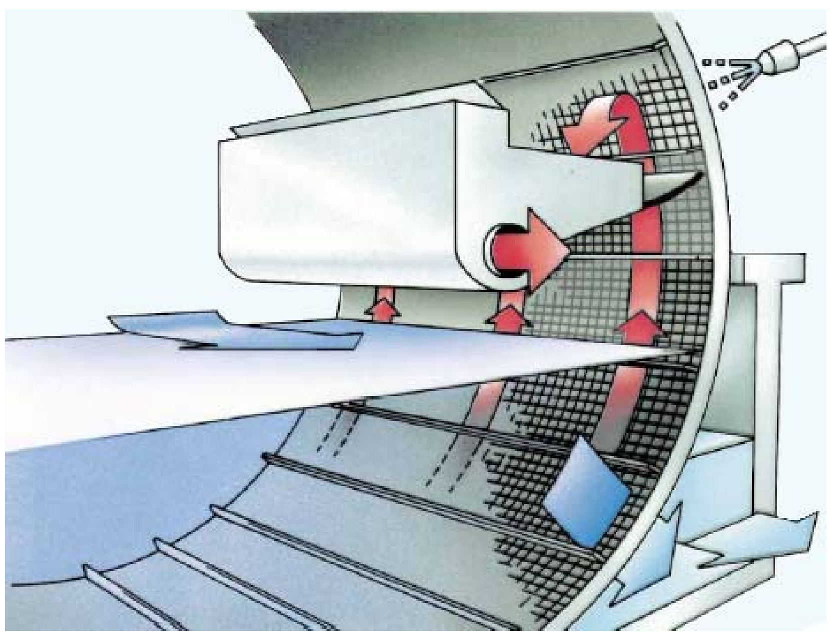


Figure 27. Microscreen drum filter operation (photo courtesy of Hydrotech AB, Sweden).

Separate effluent treatment systems should be constructed for each of the three Burrows ponds systems and the Chinook salmon raceways, for a total of four separate microscreen filter systems. The locations of the proposed treatment systems are indicated in the modified facility layout plan included in the Appendix. Effluent treatment from the nursery tanks should be tied into the proposed effluent treatment system for System I, as subsequently described. If construction of the four recommended treatment systems is restricted due to funding limitations, the microscreen filters for Burrows ponds Systems II and III should be made a priority over System I, followed by those recommended to treat raceway effluent. The System I and nursery tank clarifying basins do achieve solids settling and removal, and are near the recommended design criteria for full-flow hatchery effluent settling basins. These clarifying basins will likely achieve enough treatment to result in TSS concentrations that meet new NPDES requirements; however the drain line from the clarified effluent channel to the North Fork River needs to be increased from 24 inches in diameter to 48 inches in diameter. Microscreen filter improvements are recommended if System I is to be operated in reuse configuration. A treatment system for the holding ponds (including those converted to raceways for Coho salmon) was not designed because it would be extremely difficult to retrofit the existing infrastructure. Alternative rearing space for the Coho salmon smolt program should be developed at Dworshak NFH or a nearby facility.

Prior to developing a recommendation for the installation of microscreen filters in Systems II and III, the modification of existing system biofilter basins into full-flow effluent treatment settling basins was investigated. This option was dismissed because it requires significant alterations to the existing basin infrastructure, and the resulting solids removal efficiency would not outweigh the costs. Modifying the existing biofilter basins into full-flow settling basins requires alterations to the basin inlets and outlets to convert the water flow through the basins to flow down the length of the basins instead of across the width.

The four proposed microscreen filter systems are incorporated into the existing hatchery infrastructure and grade elevations such that filtration is achieved by gravity-flow of effluent from fish culture systems through the proposed microscreen filters. Pumping is only required when Burrows ponds reuse systems are operated to pump filtered reuse water through the aeration towers and back to the Burrows ponds. Pumping of effluent prior to treatment is not desirable because it causes waste solids to breakup into smaller particles, which are harder to remove. Based on the dimensions and elevations provided in the original hatchery design drawings, it is feasible to install microscreen filter systems throughout the hatchery such that there are no effluent pumping requirements. Note that the hatchery construction drawings were not marked as being as-built drawings; site surveys are required for the detailed design process.

FEASIBILITY

Microscreen drum filtration can be implemented utilizing existing infrastructure at the hatchery. It is recommended that the same size and type of microscreen filter be installed throughout the facility to make required maintenance less cumbersome and decrease the number of spare parts that must be kept on-hand. A total of 13 microscreen filters are required for the effluent treatment systems outlined for the entire hatchery. A high-pressure water system is required to provide backwash water to all of the microscreen filters. The current high-pressure water system in the fire suppression building could potentially be modified to provide backwash water to the microscreen filters; otherwise a new centralized booster pump system, or multiple systems, should be installed. Microscreen filtration systems should be enclosed within a basic structure to protect and extend the life of filtration equipment.

The proposed microscreen filters are Hydrotech model HDF 2007-2H drum filters, which are open-frame sump models with integral influent channels and effluent weirs. The filters for each system should be installed in multi-chambered concrete sumps, discharging filtered water into their respective surrounding concrete sumps. The influent channel walls for each microscreen filter also serve as emergency bypass weirs. For this reason, the influent channel walls have a fingerweir design to increase the weir length and accommodate the emergency overflow volume. Each microscreen filter shall have at least 170 ft^2 of 60 µm filter media and corresponding treatment capacity of 7,770 gpm at a TSS concentration of 15 mg/L. The Hydrotech HDF 2007-2H filters are approximately 11 feet long and 7.5 feet wide, with a drum diameter of 6.5 feet. A picture of a microscreen filter installation similar to the systems proposed for Dworshak NFH is provided in Figure 28.

Figure 28. Microscreen filters in a multi-chambered sump with access grating.

Burrows Ponds Systems II and III

The biofilter beds in Systems II and III should be eliminated and microscreen filters should be installed in the existing biofilter basins. The existing biofilter beds in Systems II and III do not function effectively as biofilters and are not required. Waste solids are trapped within the beds, degrading water quality and providing a reservoir for pathogens. Reuse systems require biofiltration processes to oxidize ammonia produced by fish if the amount of makeup water added to the systems is not enough to dilute the levels of ammonia in reuse water from becoming toxic to fish. Makeup water rates of 10% of the system flow are used when Systems II and III are operated in reuse configuration, which is adequate to maintain safe levels of unionized ammonia in fish culture water without the requirement of a biofiltration process because of low biomass loading within the systems. Fish biomass and feed loadings in reuse systems affect the amount of ammonia produced within the systems, while pH also factors into ammonia toxicity.

Mass balance calculations were conducted to determine expected maximum unionized ammonia concentrations in reuse water if the biofilters were eliminated in Systems II and III. To prevent toxicity to fish, the concentration of unionized ammonia in culture water should be maintained below 0.0125 mg/L. A summary of mass balance calculations for System II is included in the Appendix. Mass balances were calculated for February operation of System II in reuse configuration with a 10% makeup water flow. February is near the end of system reuse operation, representing the worst-case scenario for feed and biomass loading to the system and subsequent ammonia production. System II was used for the analysis because it is historically operated in reuse from December through February; whereas Systems I and III are not always operated in reuse. Mass balance calculations for worst-case scenarios indicate expected unionized ammonia concentrations will be significantly less than the maximum safe level allowed. Hatchery staff began monitoring ammonia concentrations in each of the systems on a weekly basis in the fall of 2007, and monitoring results also support elimination of the biofilter beds in Systems II and III.

Based on the dimensions and elevations provided in the hatchery construction drawings, it is feasible to install microscreen filters within the existing concrete biofilter basins in Systems II and III and eliminate intermediate pumping from the Burrows ponds channel pump sumps. In both systems, all of the existing biofilter media, media support structures, inlet pipes, effluent launderers, air scour system manifolds, and chain-and-flight sludge scraper systems need to be removed from the basins. Waste solids should also be removed and the basins should be pressure-washed and disinfected prior to microscreen filter installation. The basin modifications required to accommodate the proposed effluent treatment microscreen filters for Systems II and III are very similar. The conceptual designs in both cases minimize the scope of necessary modifications to the basins and utilize existing influent and effluent piping and infrastructure to the extent possible. Three HDF 2007-2H microscreen drum filters are required to treat pond effluent in System II and four are required to treat System III effluent. Plan and section views of the proposed microscreen filter effluent treatment systems for Burrows ponds Systems II and III are provided in Figures 29–31. Section views are only provided for System III, but elevations are identical in System II.

In order to ensure gravity-flow treatment of Burrows pond effluent while utilizing the existing 30-inch diameter supply line to each basin and concrete influent channels, only two filters can be installed per existing supply line and concrete influent channel. The water pressure head required to transport water through the 30-inch diameter supply line and concrete supply channel for the flowrate associated with more than two microscreen filters can not be accommodated without pumping or significantly increasing the size of the influent manifold and concrete influent channel. As previously indicated, gravity-flow effluent treatment systems are ideal to avoid un-necessary breakup of waste solids and increase microscreen filter removal efficiencies. Additionally, the piping and infrastructure modifications that would be required to make either system function with more than two filters per basin increases the complexity of the retrofit and may not be feasible depending on the integrity of the existing infrastructure.

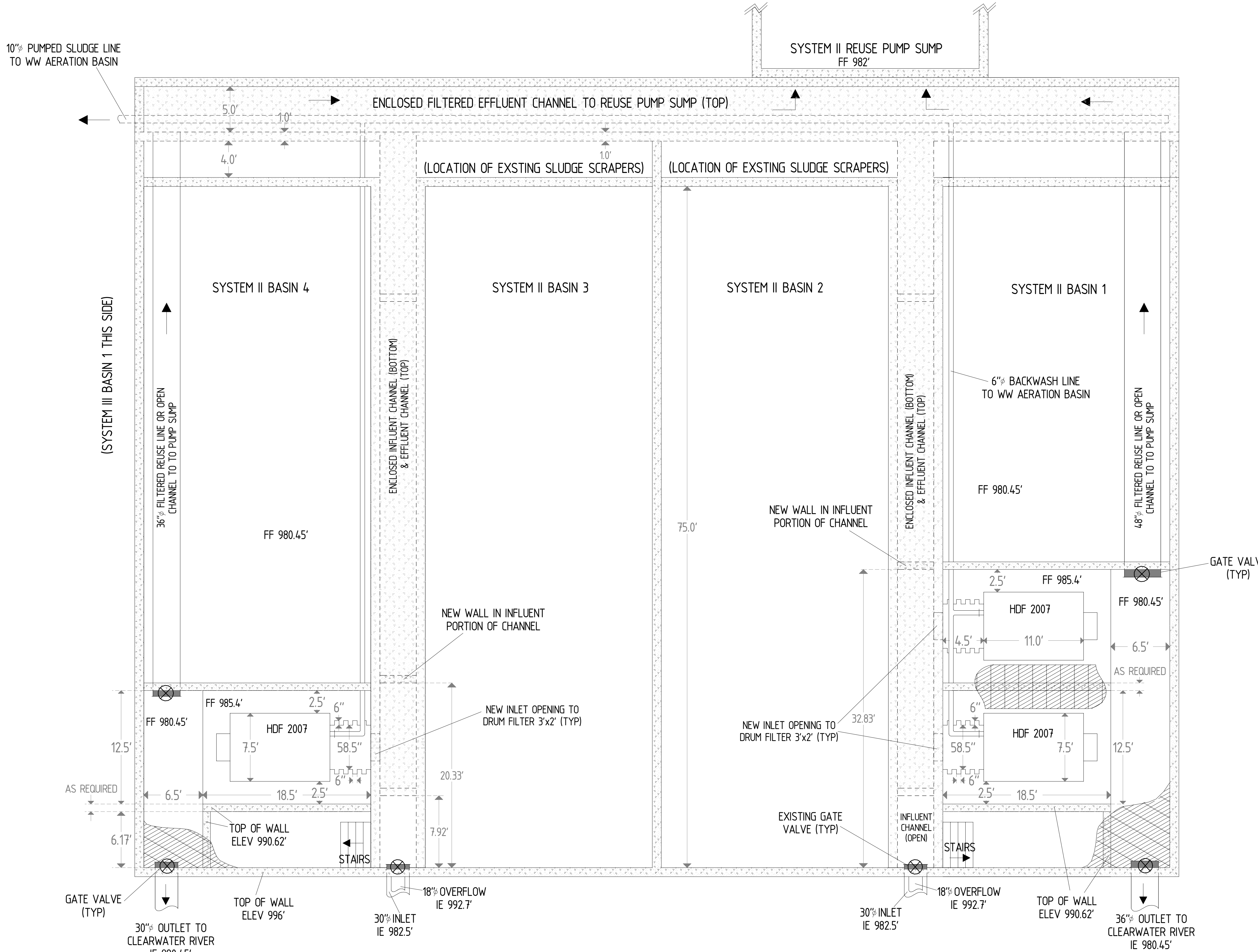


Figure 29. Plan view of proposed System II microscreen filtration system.

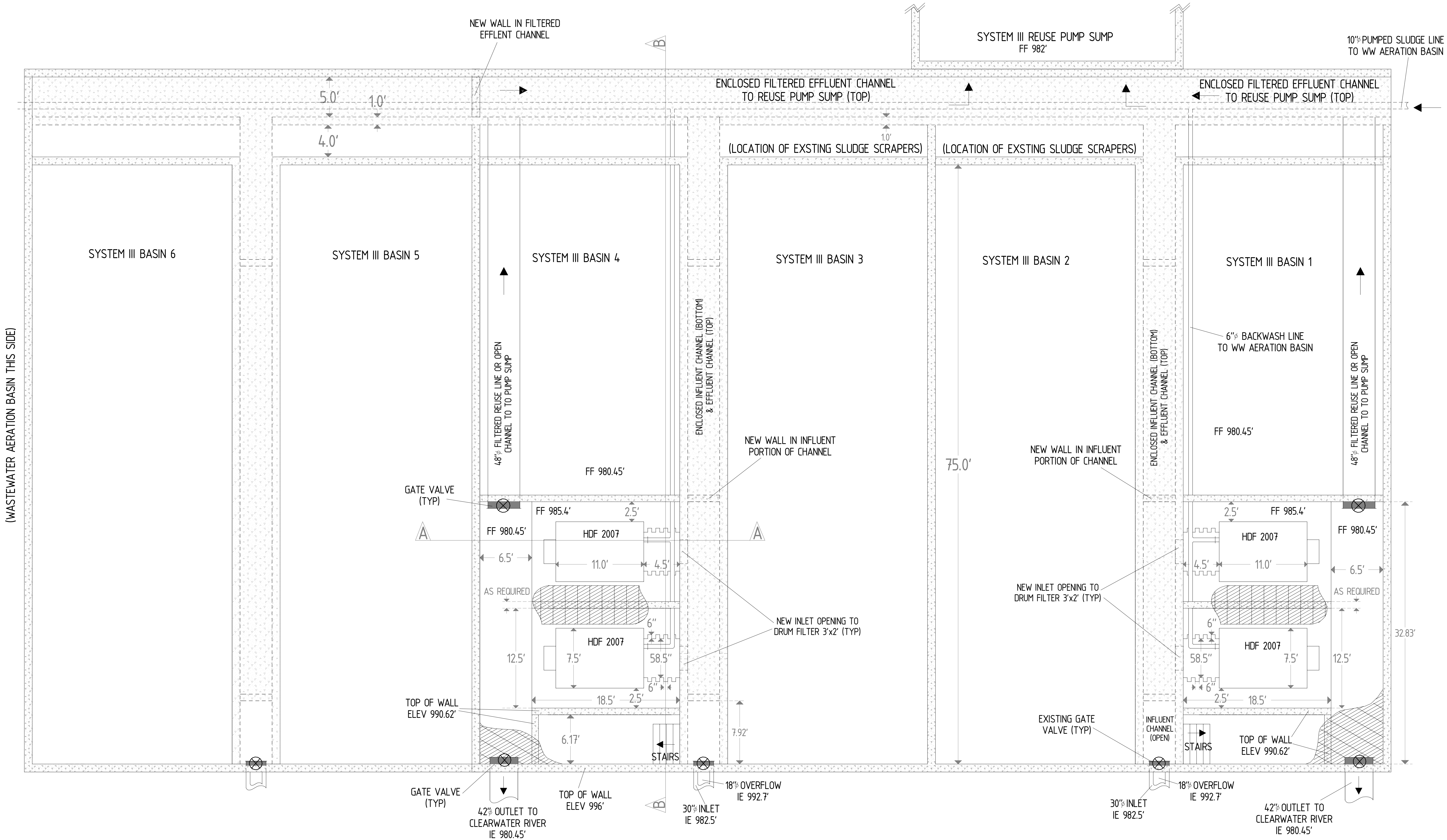


Figure 30. Plan view of proposed System III microscreen filtration system.

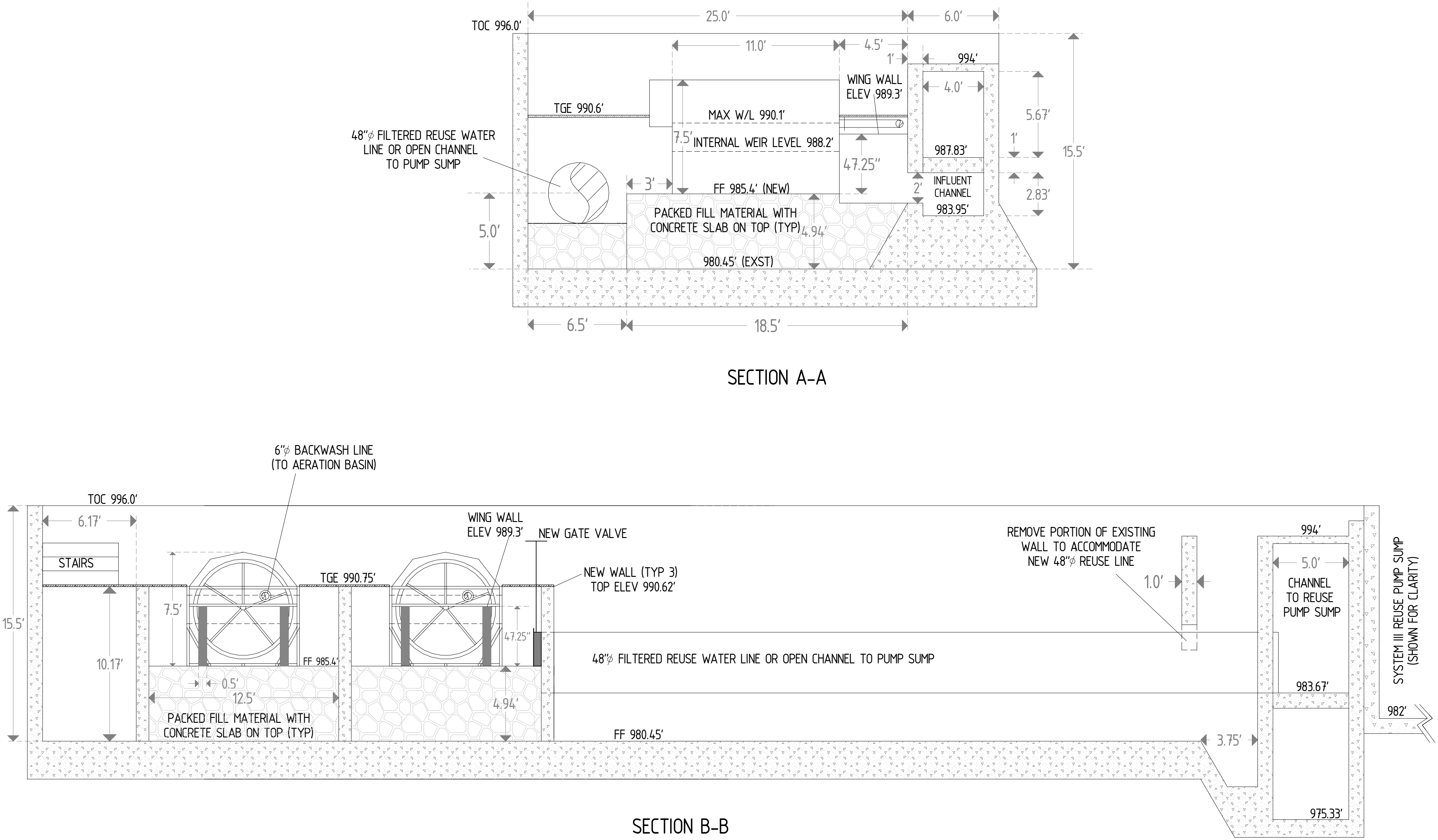


Figure 31. Section views of proposed System III microscreen filtration system.

Two microscreen filters should be installed in System II biofilter basin #1 and one microscreen filter should be installed in System II basin #4. For System III, two microscreen filters should be installed in basin #1 and two filters should be installed in basin #4. Basin modifications require the addition of several concrete walls to separate microscreen filter areas from the rest of the existing basins and to create individual sumps for microscreen filters. New walls are also required in the influent portion of the basin channel after the last microscreen filter to prevent water from stagnating in the rest of the channel. A new wall is required in each system within the filtered effluent channel to shorten the channel and direct filtered effluent to the reuse system pump sump. The sump area surrounding the microscreen filters should be covered with grating to provide equipment access. Grating will also limit the introduction of foreign objects/animals into reuse water.

The finished floor supporting the microscreen filters needs to be approximately five feet above the existing finished floor elevation of the biofilter basins. This higher elevation will allow effluent to flow by gravity from the Burrows ponds, through the microscreen filters, and to discharge. The new finished floor for the microscreen filters can be built entirely from concrete, or can be compacted gravel with a concrete slab at the top, as determined by structural analysis. An opening must be cut in the existing basin influent channel to create a new inlet for each microscreen filter. The inlet should be 3 feet wide and 2 feet high, which will provide an entrance velocity of less than 1.5 ft/sec into each microscreen filter influent channel.

Each retrofitted basin requires two new discharge lines: one to discharge filtered water to the Clearwater River and one to discharge filtered water to the reuse system effluent channel where it will flow to the reuse pump sump. Gate valves are required on all discharge lines so that effluent can be directed to the desired location. Installation of the drain lines that discharge effluent to the Clearwater River requires coring through the front of the existing basin wall to accommodate each new line. Installation of the drain lines that discharge filtered effluent to the system reuse channels requires coring through the effluent channel walls. The existing 18-inch diameter overflow lines can be abandoned in place.

Microscreen filter backwash should be directed to the wastewater treatment aeration basin that is adjacent to the System III biofilter basins. This can be achieved by connecting the 6-inch diameter backwash lines from the microscreen filters to the existing 10-inch diameter pumped sludge line shared by Systems II and III.

The proposed microscreen filtration systems will provide the capacity for full-flow filtration of effluent from Burrows ponds in Systems II and III at the identified maximum flowrate of 600 gpm per pond. Water supply flowrates to Burrows ponds are not regularly measured, but reportedly vary from 450 gpm to 600 gpm. The filtration systems outlined provide treatment capacites of 23,300 gpm and 27,900 gpm for Systems II and III effluent flows, respectively. These filtration capacities provide a safety factor of 1.5 for each system at the maximum system flowrates of 15,000 and 20,400 gpm. The safety factor is provided to prevent overwhelming microscreen filters when ponds are cleaned. Pond cleaning results in a sudden increase in the concentration of solids in pond effluent, above the 15 mg/L TSS concentration, which is the design point for sizing the systems. As such, only one or two ponds should be cleaned at any one time per system.

System I Burrows Ponds

Three microscreen drum filters are required to treat effluent from the 25 Burrows ponds in System I. These three microscreen filters should be installed in the existing System I clarifying basins, one filter per basin. As previously mentioned, the existing clarifying basins do settle a portion of the waste solids suspended in pond effluent, but the 24-inch diameter discharge line to the North Fork River is too small for the 15,000 gpm effluent flowrate when the system is not operated in water reuse. Additionally, greater solids removal efficiencies are desirable if the system is operated in reuse. Waste solids that have settled to the bottom of the basins are stirred up when the chain-and-flight sludge scraper systems are operated, re-introducing these solids into the culture water. Nutrient leaching also occurs as waste solids remain on the basin bottoms, increasing biochemical oxygen demand and decreasing the dissolved oxygen content of water. The clarified water from the basins will likely meet NPDES discharge requirements to the North Fork, but would negatively impact fish health during reuse operation.

Plan and section views of the proposed microscreen filtration system to treat System I Burrows ponds effluent are provided in Figures 32–33. The conceptual design of the System I microscreen filter system is similar to those proposed and described for Systems II and III and utilizes existing infrastructure to the extent possible. Some modifications are required to the existing System I clarifying basins to accommodate microscreen filtration equipment and maintain the gravity-flow nature of the effluent treatment process. The existing chain-and-flight sludge scraper systems, slotted concrete influent weir walls, and effluent fingerweirs should be removed from the basins where the drum filters are to be installed. Solids should also be removed from the basins and they should be pressure-washed and disinfected prior to equipment installation.

The existing drain lines from the System I ponds to the clarifying basins can be utilized for the proposed effluent treatment system. A concrete wall must be constructed in each basin to separate the drum filter area from the rest of the basin. A new wall is also required in the influent channel after the last microscreen filter to prevent water from stagnating in the rest of the channel. Grating should be installed in the sump area surrounding the microscreen filters to provide equipment access. The finished floor underneath the microscreen filters needs to be 1.5 feet above the existing finished floor elevation of the clarifying basins. This higher elevation will allow effluent to flow by gravity from the System I Burrows ponds, through the filters, to discharge.

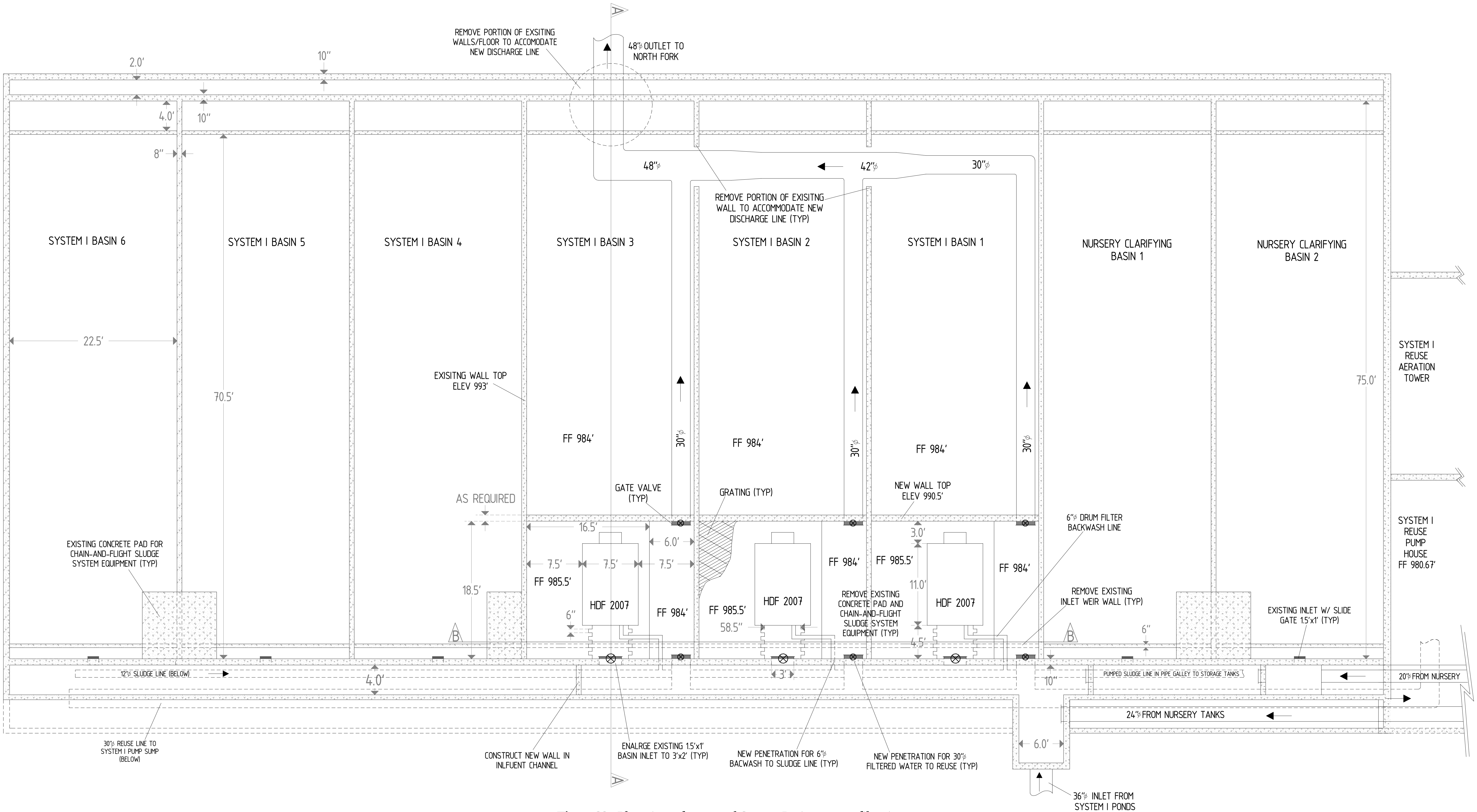
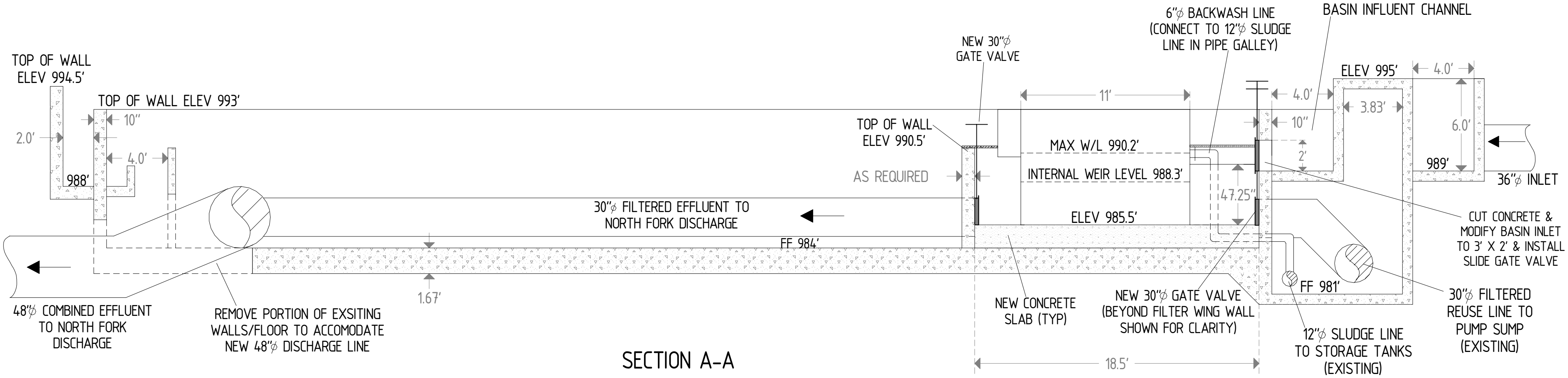


Figure 32. Plan view of proposed System I microscreen filtration system.



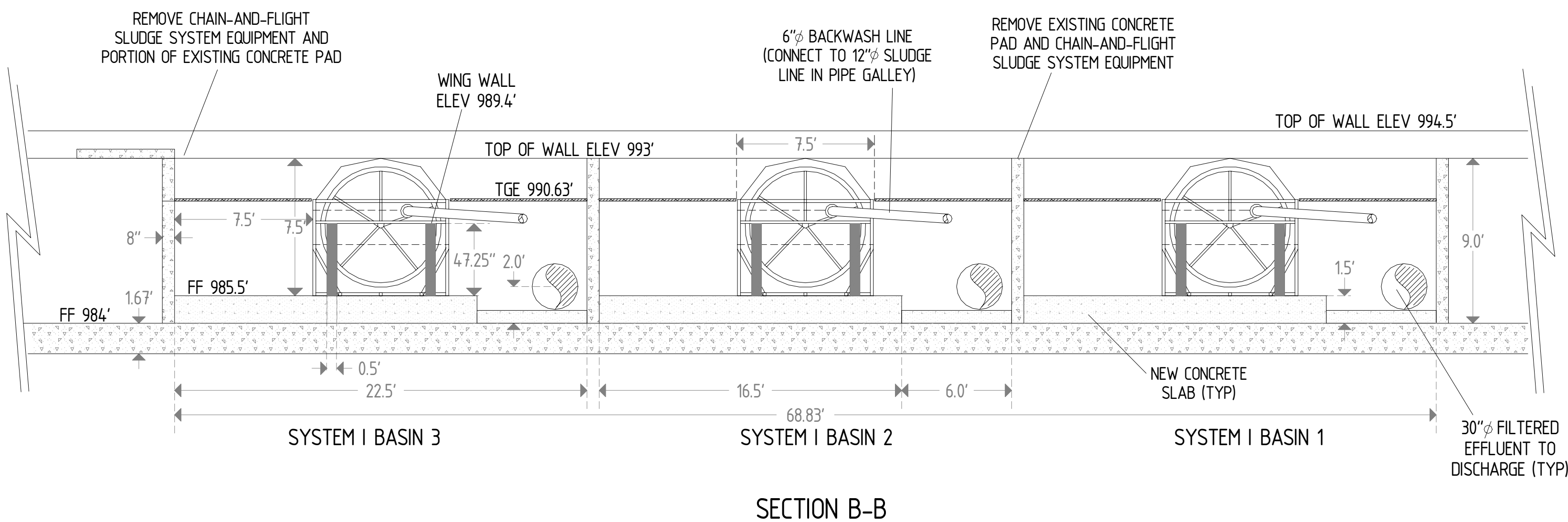


Figure 33. Section views of proposed System I microscreen filtration system.

Each clarifying basin currently has a rectangular inlet that is 1.5 feet wide and 1.0 foot high. These inlets must be enlarged to be 3 feet wide and 2 feet high in order to provide an entrance velocity of less than 2 ft/sec into the microscreen filter channels. Similar to microscreen filter effluent treatment for Systems II and III already discussed, each retrofitted basin requires two new discharge lines: one to discharge filtered water from the hatchery and one to discharge filtered water to the reuse system pump sump. The discharge from the System I clarifying basins is directed to the North Fork of the Clearwater River instead of to the Clearwater River as in Systems II and III. Due to elevation constraints, the existing System I effluent basin drain channel can not be utilized to discharge filtered water from the hatchery and a new 48-inch diameter discharge line is required to implement the proposed System I filtration system. Gate valves are required on the discharge lines from each microscreen filter sump so that effluent can be directed to the desired location.

Installation of new hatchery discharge drain lines from the microscreen filter sumps require portions of the existing basin walls and floor to be removed, as indicated in the system plan and section drawings. Two new penetrations are required through the front wall of the each of the basins that will house microscreen filters. One penetration needs to accommodate the 30-inch diameter reuse drain line from each proposed filter sump, which will connect to the main 30-inch diameter reuse drain line for the system. A penetration is also required in each sump to connect the 6-inch diameter microscreen filter backwash line to the suction side of the 12-inch diameter pumped sludge line. The two existing sludge pumps should be utilized to pump backwash from filters in System I to the outdoor digester storage tanks.

The proposed microscreen filter system for System I Burrows ponds can also be used to treat effluent from the nursery tanks. Nursery building effluent flows through one of two existing process drain pipes to the clarifying basins. Nursery tank effluent is discharged into the inlet channel of the clarifying basins in one of two places, as indicated in Figure 32. Nursery tank effluent is currently separated from the System I Burrows pond effluent and treated in two of the existing clarifying basins, however, the infrastructure exists to combine the effluents from the nursery tanks and System I Burrows ponds. The finished floor elevation of the nursery building is 995 feet and the water level in the nursery tanks is maintained at 1.8 feet, providing an approximate elevation differential of 5 feet between the nursery tank water level and the maximum water level of 990.2 feet in the proposed System I microscreen filters.

Chinook Raceways

Three HDF 2007-2H microscreen drum filters are required to treat effluent from the 30 Chinook production raceways. Reported operational water supply flowrates for the raceways vary between 400 gpm and 500 gpm. Operated at the maximum flowrate of 500 gpm, the total system flowrate is 15,000 gpm and the proposed microscreen filter treatment system provides the capacity to treat 23,300 gpm (a safety factor of 1.5). The microscreen filters should be installed in a multi-chambered concrete sump, and grating should be installed over the open sump area to provide access to equipment for maintenance purposes. Plan and section views of the proposed raceway effluent treatment microscreen filter system are provided in Figure 34.

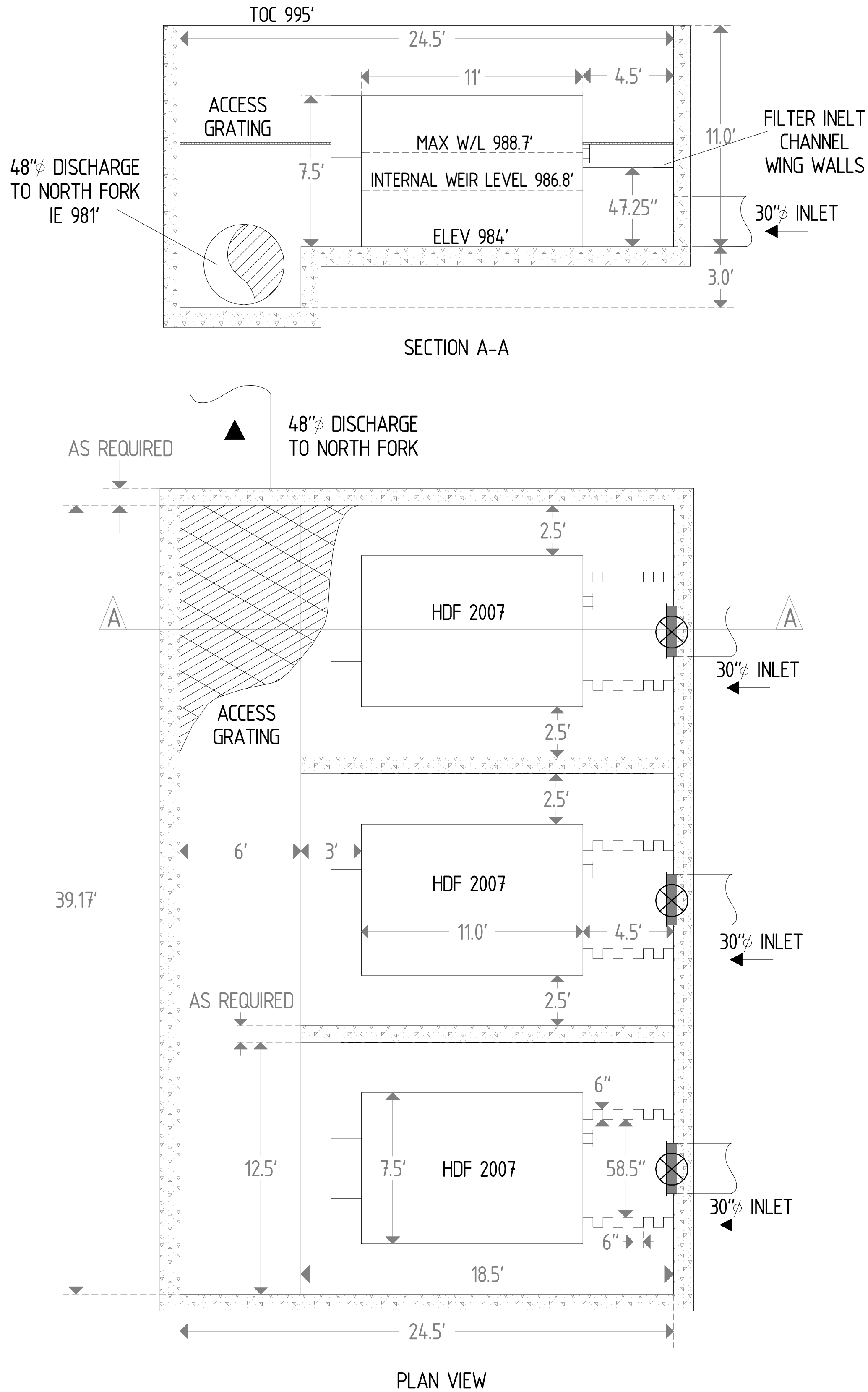


Figure 34. Plan and section views of the proposed Chinook raceway effluent treatment system.

The new microscreen filter sump should be constructed at an elevation that allows Chinook raceway effluent to gravity-flow through the filters and be discharged to the North Fork. This is feasible based on the existing information gathered, but is ultimately dependent on future site survey information that will be collected at the detailed design level. The proposed finished floor elevation of the microscreen filter portion of the new sump is 984 feet, which is slightly above the finished floor elevation of the existing raceway wastewater pump sump; the invert elevations of the 16-inch diameter raceway cleaning flow lines entering the existing sump are 982.4 and 983.3 feet, respectively. Microscreen filter sump elevations for the gravity-flow treatment system were determined based on the raceways having a finished floor elevation of 991.54 feet and the water level in the North Fork varying between 968 feet and 980 feet. North Fork water level elevations were indicated on the conceptual design drawings for the river intake structure in the original 1966 hatchery planning documents. Space for the new multi-chambered microscreen filter sump, which will have a footprint of approximately 40 feet by 25 feet, is available in the vicinity of the existing Chinook raceway pump sump.

In order to utilize the existing infrastructure to the extent possible, bulk raceway effluent will be discharged to the new microscreen filter sump through the existing 30-inch diameter bulk effluent line between the A Bank and B Bank raceways. However, several modifications to the existing raceway effluent process piping are required. A gate valve is required on the existing 36-inch diameter line that discharges bulk raceway effluent to the North Fork next to the fish ladder, and a new 36-inch diameter line is needed to transfer effluent to the new microscreen filter sump. The new 36-inch diameter line should tie into the 30-inch diameter bulk raceway effluent line midway between the A Bank and B Bank raceways. A new 48-inch diameter discharge line is required from the filter sump to the North Fork. Raceway cleaning flows should still be directed through the 16-inch diameter lines to the existing wastewater pump sump and pumped to the settling pond at the end of the peninsula. Backwash from the microscreen filters could potentially tie into the backwash/solids system to the wastewater treatment aeration basin or could be directed to the settling pond. Both options require the backwash to be pumped if the filter sump is constructed at the proposed elevation.

If the construction of the raceway microscreen filtration system to accommodate gravity-flow treatment of effluent is not feasible due the existing elevations after further investigation, the effluent can be pumped to the microscreen filters. Pumping is not the preferred option though because it shears solids into smaller particles and results in less efficient removal.

Benefits – A comprehensive waste management plan can be established at Dworshak NFH by implementing the proposed microscreen filtration systems in combination with best management practices. In addition to being a good environmental steward, implementation of the filtration systems will enable the hatchery to meet current and future NPDES permit restrictions, maintaining beneficial use categories of the receiving waters.

Microscreen filtration of Burrows pond effluent during reuse will improve water quality and may reduce the hatchery's dependency on chemical treatments to counteract disease issues. A mass-balance analysis was conducted to calculate expected ammonia levels in reuse systems operated with 10% makeup water supplies at the biomass loadings and feeding rates identified by hatchery staff. Calculations for the month with the heaviest loading rate indicated that the un-ionized ammonia concentration would be well under any concentration that would cause alarm. Instead of functioning as biofilters, the beds in Systems II and III currently serve as areas for solids to accumulate and pathogens to multiply, leading to poor water quality and fish health.

Obstacles – The existing hatchery infrastructure was incorporated into the proposed effluent treatment systems to the extent possible in order to minimize necessary infrastructure renovations. However, the installation of new process piping and concrete infrastructure is required along with removing portions of existing walls, as previously indicated. The renovations required to implement the proposed filtration systems are feasible, but renovations are fairly significant. Each microscreen filtration system includes extra capacity to accommodate the increased solids loading resulting from pond/raceway cleaning; however only 1–2 ponds or raceways should be cleaned in each system at one time.

Cost Opinion – System II Effluent Treatment System

Item	**Quantity**	**Unit Cost**	**Cost[1]**
Removals[2]	1	Lump Sum	$25,000
Filter Buildings and Sumps[3]	1,340 ft^2	$325/$ft^2$	$436,000
HDF 2007-2H Drum Filters[4]	3	$69,000	$207,000
Process Piping and Valves[5]	1	Lump Sum	$125,000
Electrical	1	Lump Sum	$25,000
Miscellaneous Labor and Installation	1	Lump Sum	$54,000
Subtotal			$872,000
Design	10%	$872,000	$88,000
Construction Administration	5%	$872,000	$44,000
Contractor Overhead/Profit	20%	$872,000	$175,000
Contingency	10%	$872,000	$88,000
		TOTAL	**$1,267,000**

[1]All costs rounded up to the nearest $1,000
[2]Assumes hatchery maintenance staff removes the existing biofilter internals: media, media support beams, aeration piping, and sludge scraping systems and pressure-washes and disinfects the basins
[3]Assumes a basic covering/enclosure
[4]Assumes the use of high pressure microscreen backwash water the from fire maintenance building
[5]Process piping estimated at $200/$ft^2$ including installation, excavation, and backfill

Cost Opinion – System III Effluent Treatment System

Item	Quantity	Unit Cost	Cost[1]
Removals[2]	1	Lump Sum	$25,000
Filter Buildings and Sumps[3]	1,650 ft^2	$\$325/ft^2$	$537,000
HDF 2007-2H Drum Filters[4]	4	$69,000	$276,000
Process Piping and Valves[5]	1	Lump Sum	$125,000
Electrical	1	Lump Sum	$25,000
Miscellaneous Labor and Installation	1	Lump Sum	$54,000
Subtotal			$1,042,000
Design	10%	$1,042,000	$105,000
Construction Administration	5%	$1,042,000	$53,000
Contractor Overhead/Profit	20%	$1,042,000	$209,000
Contingency	10%	$1,042,000	$105,000
		TOTAL	**$1,514,000**

[1]All costs rounded up to the nearest $1,000
[2]Assumes hatchery maintenance staff removes the existing biofilter internals: media, media support beams, aeration piping, and sludge scraping systems and pressure-washes and disinfects the basins
[3]Assumes a basic covering/enclosure
[4]Assumes the use of high pressure microscreen backwash water the from fire maintenance building
[5]Process piping estimated at $\$200/ft^2$ including installation, excavation, and backfill

Cost Opinion – System I Effluent Treatment System

Item	Quantity	Unit Cost	Cost[1]
Removals[2]	1	Lump Sum	$50,000
Filter Building and Sumps[3]	1,250 ft^2	$325/$ft^2$	$407,000
HDF 2007-2H Drum Filters[4]	3	$69,000	$207,000
Process Piping and Valves[5]	1	Lump Sum	$205,000
Electrical	1	Lump Sum	$25,000
Miscellaneous Labor and Installation	1	Lump Sum	$54,000
Subtotal			$948,000
Design	10%	$948,000	$95,000
Construction Administration	5%	$948,000	$48,000
Contractor Overhead/Profit	20%	$948,000	$190,000
Contingency	10%	$948,000	$95,000
		TOTAL	**$1,376,000**

[1]All costs rounded up to the nearest $1,000
[2]Assumes hatchery maintenance staff removes the existing sludge scraping systems and pressure-washes and disinfects the basins
[3]Assumes a basic covering/enclosure
[4]Assumes the use of high pressure microscreen backwash water the from fire maintenance building
[5]Process piping estimated at $200/$ft^2$ including installation, excavation, and backfill

Cost Opinion – Chinook Raceway Effluent Treatment System

Item	**Quantity**	**Unit Cost**	**Cost[1]**
Modifications to Existing Yard Piping	1	Lump Sum	$50,000
Filter Building and Sump Excavation	1	Lump Sum	$50,000
Filter Building and Sump[2]	1,125 ft^2	$325/$ft^2$	$366,000
HDF 2007-2H Drum Filters[3]	3	$69,000	$207,000
Process Piping and Valves[4]	1	Lump Sum	$155,000
Electrical	1	Lump Sum	$25,000
Miscellaneous Labor and Installation	1	Lump Sum	$50,000
Subtotal			$903,000
Design	10%	$903,000	$91,000
Construction Administration	5%	$903,000	$46,000
Contractor Overhead/Profit	20%	$903,000	$181,000
Contingency	10%	$903,000	$91,000
		TOTAL	**$1,312,000**

[1]All costs rounded up to the nearest $1,000
[2]Assumes a basic covering/enclosure
[3]Assumes the use of high pressure microscreen backwash water the from fire maintenance building
[4]Process piping estimated at $200/$ft^2$ including installation, excavation, and backfill

2. Burrows Pond Renovation for Improved Operation and Fish Health

Description

Dworshak NFH has a total of 84 outdoor Burrows ponds that are used to rear juvenile steelhead. The majority of Burrows ponds are used 10–11 months each year, from the end of May through mid-April. The dimensions and operational layout of the Burrows ponds at Dworshak NFH are presented in Figure 16. The Burrows ponds at Dworshak NFH have poor operational hydrodynamics, which results in significant dead zones and allows for the accumulation of waste solids within the pond culture water.

Each pond has two water supply inlet risers, which were designed to produce water velocities of 0.85 ft/sec along the outside pond walls, but this velocity is not achieved under normal pond operation. Additionally, the orientation of the inlets and the physical layout of the ponds result in lower velocities and more dead zones near the center dividing wall. Effluent from each pond drains through two rectangular drain sumps located on opposite sides of the center dividing wall. Concrete plug modifications that were made to the drain sumps in the 1980s amplified the dead zones within each pond. The existing 12-inch diameter drain lines from individual pond drain sumps are too large for the current flow, resulting in low operational drain line velocities. Assuming the 450–600 gpm of water supplied to each pond exits both drain sumps equally, the velocity in the 12-inch diameter drain line from one drain sump before it combines with the effluent from the other pond drain sump is less than 0.6–0.9 ft/s. Since a velocity of 2–3 ft/s is necessary to transport waste solids through drain lines, uneaten feed and fish feces likely accumulate in drain sumps and associated piping, degrading water quality.

Waste solids in dead zones within the ponds break down into smaller particles and leach nutrients as they accumulate, requiring physical removal by hatchery staff. The accumulation of solids on rearing pond bottoms and in drain lines degrades water quality and negatively impacts fish health, as well as increases staff labor requirements for cleaning. Ponds are currently brushed weekly and solids are flushed directly to the river. Flushing solids from the ponds is problematic due to poor hydraulics and staff have indicated that it is difficult to get solids to move into the drains. Slots in the fish exclusion plates over the drain sumps also reportedly become plugged with solids during pond cleaning and flushing. Hatchery staff report some improvements in solids movement through ponds after implementing floating AquaMat® sweepers in the summer of 2007; however these sweepers are subject to the poor hydraulic flow characteristics within the ponds and get stuck in dead zones. Solids also risk the chance of being moved around the ponds with the sweepers and never being swept near the drains.

Recommendation

Modifications should be made to the existing Burrows ponds to improve the hydrodynamics and solids removal from the ponds. It is recommended that one or two ponds be modified and operated on a trial basis before modification of other ponds is implemented. The proposed modifications include retrofitting a Burrows pond into a mixed-cell rearing unit. With the modifications, the rectangular Burrows pond will essentially be transformed into three or four circular tanks with bottom center drains by changing the way water is supplied and removed from the pond. This mixed-cell concept has been introduced and further developed by several investigators, including Watten et al. (2000), Oca and Masaló (2007), Ebeling et al. (2005), Labatut (2005), and Labatut et al. (2007). Self-cleaning hydraulics can be achieved within circular tanks by introducing water throughout the rearing water depth in a location tangential to the tank wall. Combined with a centrally located tank bottom drain, a primary rotating current is established within the circular tank, which creates a secondary radial flow along the tank bottom and transports waste solids to the center drain. A picture of a raceway renovated into six mixed-cell units by Watten et al. (2000) at the Wellsboro Fish Culture Station (Wellsboro, PA) is provided in Figure 35.

Figure 35. Raceway renovated into six mixed-cell units at Wellsboro Fish Culture Station (Wellsboro, PA).

The mixed cell concept was initially developed for application in traditional linear raceways. Mixed-cell units are intended to provide a more homogenous rearing environment for fish in terms of water quality. Waste solids are removed more quickly from rearing areas and the rearing areas are more fully mixed with fewer hydraulic dead zones. An illustration of the hydraulic mixing in three adjacent mixed-cells is illustrated in Figure 36, as presented by Labatut (2005). A sketch of the mixed-cell experimental setup used to collect this velocity profile data is provided in Figure 37 and indicates the locations of water supply manifolds and drains. Labatut (2005) collected velocity measurements over a grid in three 18-foot square mixed-cells operated at a water depth of approximately 3.25 feet. Each cell had a bottom drain, where 20% of the water supply to the cell exited the cell, while the remaining 80% of the flow was collected in an upper side drain, as indicated in Figure 37.

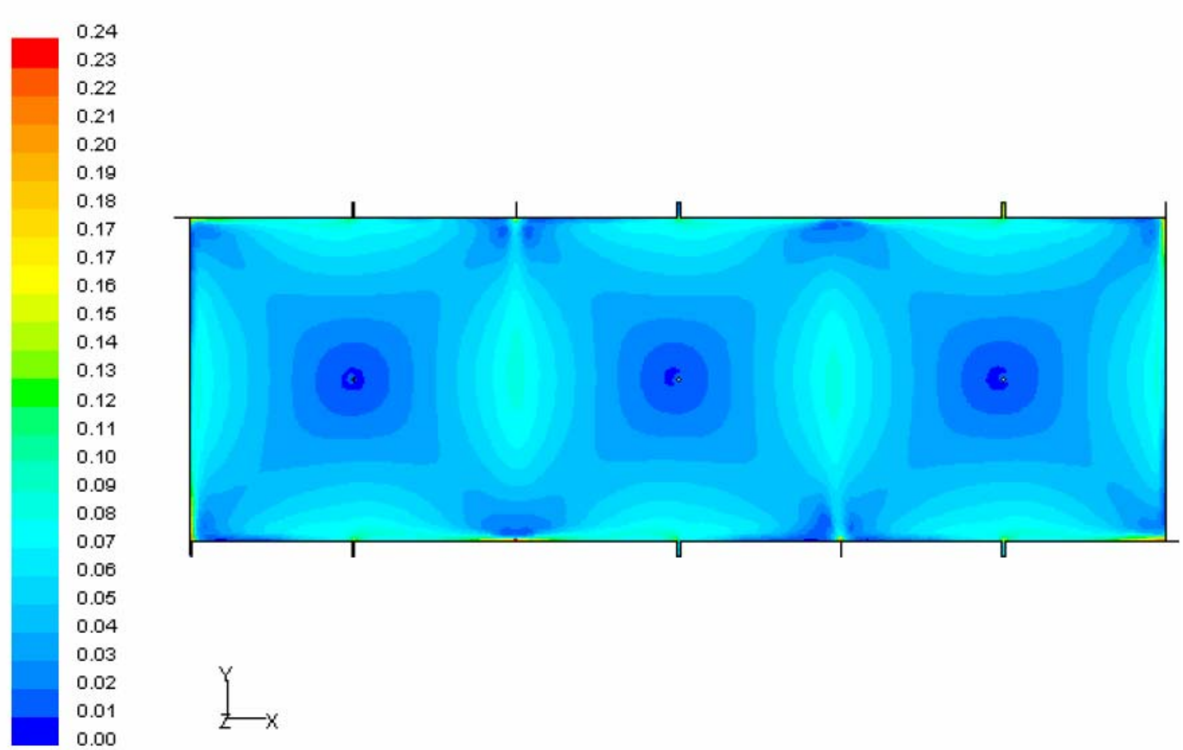


Figure 36. Contour velocity profiles (0–0.24 m/s) in a 3-cell mixed-cell rearing unit. The flowrate leaving the bottom center drain is 20% of the supply and the remaining 80% of the flow exits the tank through an upper drain on the side of each cell (from Labatut, 2005).

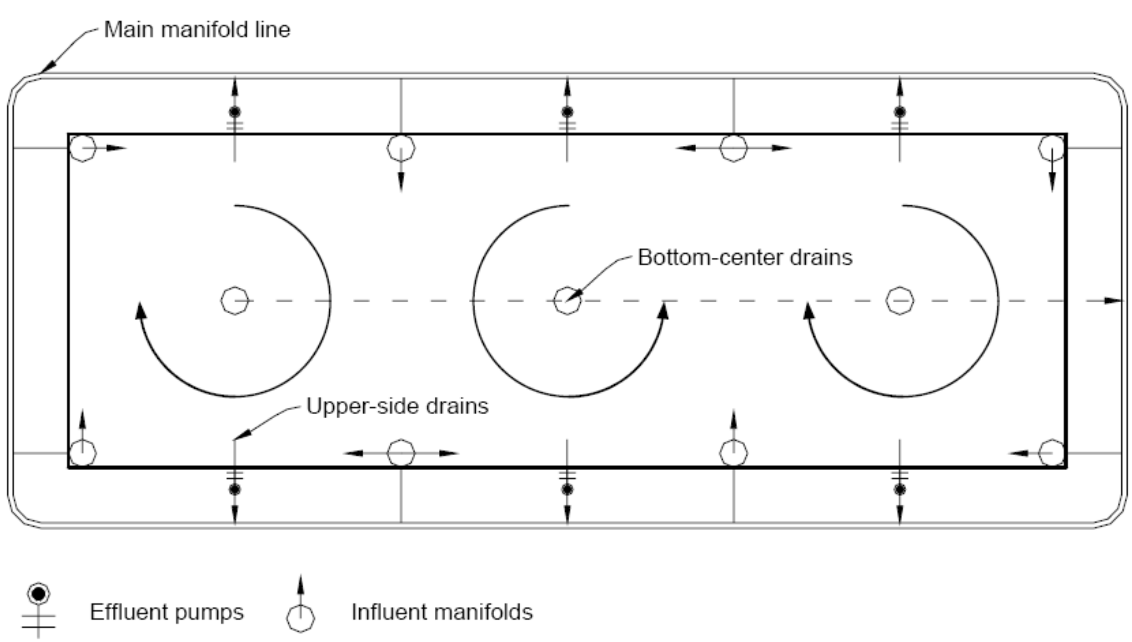


Figure 37. Mixed-cell rearing unit used to collect data in Figure 36 from Labatut (2005).

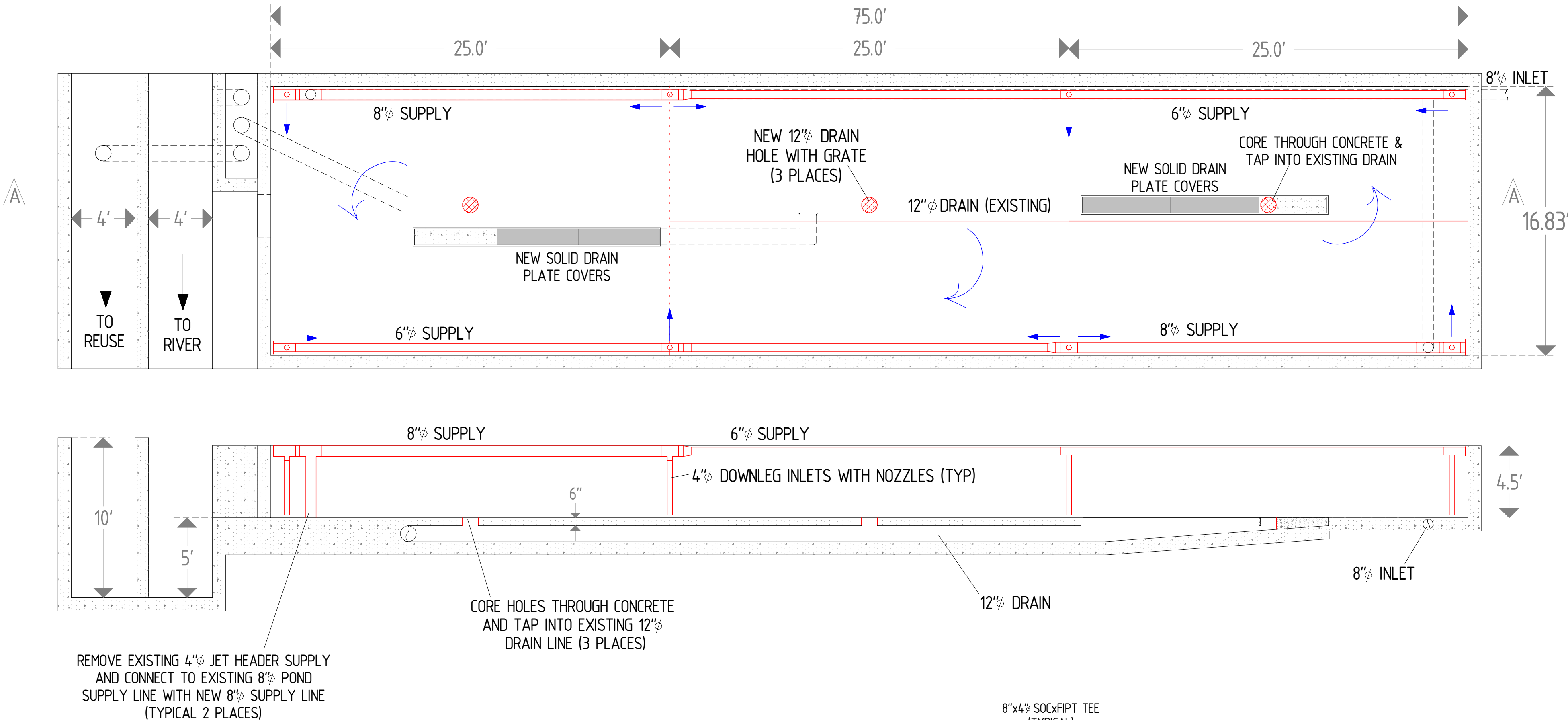
Modifying the Burrows pond into a mixed-cell rearing unit as proposed will minimize solids settling and accumulation in the pond and discharge pipes, improving water quality and dramatically decreasing the frequency of manual pond cleaning. Once modified, tests should be conducted on the pond to evaluate hydraulic characteristics and to determine the solids removal effectiveness.

FEASIBILITY

A sketch of the proposed pond modifications is provided in Figure 38. In addition to piping modifications, the removal of the center concrete wall is required to create one large, continuous volume. Supply piping modifications will result in the introduction of water into the pond at eight locations, four points along each outer wall. Water is introduced either tangentially or perpendicular to the wall at each location through inverted inlet risers, which are called downleg inlets. Downleg inlets will have threaded holes with bushings and nipples, forming water supply jets. Each downleg inlet will have 4–6 jets, evenly distributing water throughout the entire water column depth. Two of the downleg inlets will have jets on two sides, directing water in both directions, while the remainder of the downleg inlets will have jets on only one side. This water supply pattern will cause circular flows in each cell; the direction alternates from clockwise to counterclockwise with adjacent cells.

The downleg inlets are supplied from two new manifolds running along the length of the pond on each side. To accomplish this modification, both of the existing 4-inch diameter riser inlets should be removed and a new 8-inch diameter supply line should be connected to the existing 8-inch diameter supply line where it emerges from the pond bottom. In both locations, the new 8-inch diameter supply line will extend the height of the pond wall and run along the length of the pond, as indicated in Figure 38. The two new supply manifolds will be supported near the top of the pond wall using wall-mounted pipe hangers.

Modifications to the existing pond drains are required that will result in the formation of three new circular drains, one drain in the center of each mixed-cell, and the abandonment of both rectangular drain sumps. The slotted drain plates that cover the existing rectangular drain sumps should be replaced with solid drain plate covers and three new 12-inch diameter circular floor drains need to be installed that connect to the existing 12-inch diameter drain line. These drain modifications require cutting through the concrete pond bottom and tapping into the existing 12-inch diameter pond drain line. The operational water level in each pond will still be maintained using the existing external standpipes.



SUPPLY FLOWRATE	500-600 GPM	500-600 GPM
WATER DEPTH	2.5 FT	3.0 FT
VOLUME	23,606 GAL	28,327 GAL
HYDRAULIC RESIDENCE TIME	40-47 MIN	47-57 MIN
DIAMETER:DEPTH RATIO	6.7-10	5.6-8.3

EXISITING SUPPLY/DRAIN LINES IN BLACK
PROPOSED MODIFICATIONS IN RED

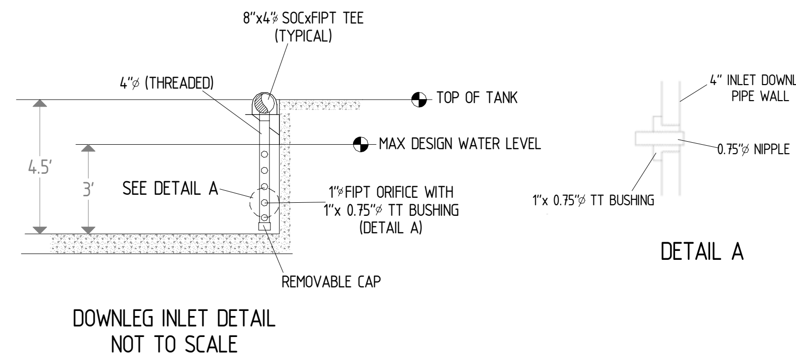


Figure 38. Proposed mixed-cell modifications to burrows ponds for conversion into three mixed-cell rearing units.

The proposed Burrows pond modification plan results in three identical mixed-cells per pond. Due to the dimensions of the existing Burrows pond, each mixed-cell will be 25 feet long and 16.83 feet wide. The resulting length to width ratio (L:W) of each mixed-cell is 1.5. While the mixed-cell concept was developed and evaluated by Watten et al. (2000) using square mixed-cells (L:W=1), more recent research by Oca and Masaló (2007) evaluates flow characteristics of rectangular mixed-cells. Oca and Masaló (2007) experienced excellent success achieving circular tank hydraulics in a rectangular tank with a L:W of 0.95. Results also indicated that a L:W of 1.43 was successful and did not result in dead zones in the mixed cell unit, but dead spaces were observed in a mixed-cell with a L:W of 1.91. The Burrows pond modifications as presented propose the formation of three mixed-cells per pond. The number of mixed cells could be increased to four cells per pond, resulting in cells that are 18.75 feet long and 16.83 feet wide, which decreases the L:W to 1.1. Increasing the number of mixed-cell units to four will slightly increase the cost of the modification with the addition of two more downleg inlets and one more center drain. These costs are not significant for the renovation of one pond, but would be considerable with the renovation of all 84 Burrows ponds.

In addition to length to width ratios, the ratio of the depth of water to the size of tanks is important for self-cleaning circular tank hydraulics. Diameter to depth ratios between 4:1 and 6:1 are recommended to promote self-cleaning tank characteristics. The Burrows ponds are currently operated at 2.5 feet of water depth, which would provide a diameter:depth ratio of 6.6:1 to 10:1 for each new mixed-cell; the ratio varies since the mixed-cell units are not dimensionally square. If the water depth is increased to 3.0 feet, the diameter to depth ratio is 5.6:1 to 8.3:1, which is preferred. The water pressure head is available from the main aeration tower sump to increase the depth of the pond six inches. The hydraulic residence time in the mixed-cell tank would be 47–57 minutes operated at 3.0 feet of water depth for water supply flowrates of 500–600 gpm. The hydraulic residence time should be maintained below 60 minutes.

As an alternative to the proposed mixed-cell rearing unit modification, five 12-foot diameter circular, dual-drain fish culture tanks could be installed within the Burrows pond. This option requires the removal of the center pond dividing wall in addition to water supply and drain line modifications. Tank drain lines could be installed on the existing finished floor of the Burrows pond if circular tanks are provided with skirts to allow drain piping underneath. Unlike the proposed mixed-cell modification where the pond fish culture volume will be maintained at the current level or increased slightly, the installation of circular tanks will result in a decrease in the available fish culture volume per pond. The fish culture volume will decrease by 29% if the 12-foot diameter circular tanks are operated at the recommended water depth of four feet. The available volume decreases by 47% of the current pond volume if the five tanks are operated at a water depth of three feet. Installing tanks larger than 12 feet in diameter will not allow good access around the tanks in the ponds.

Benefits – Renovating Burrows ponds into mixed-cells will improve the waste solids removal from the ponds. The water quality within renovated ponds will be improved as solids will no longer accumulate in dead zones leaching nutrients and degrading the fish rearing environment. The water supply and drain modifications will result in uniform water quality throughout the mixed-cells. Water will be supplied to the entire water column and the circular pattern created in each cell will transport waste solids to the new drain at the cell center. Ideally, two Burrows ponds would be renovated into mixed-cell units and operated on a trial basis; one pond would be modified into three mixed-cells and one pond renovated into four mixed-cells. The operation of both renovated ponds and the efficiency of waste solids removal from each one could be evaluated and compared with the cost of the renovations. The alternative installation of circular, dual-drain rearing tanks within the Burrows ponds will achieve similar results as the proposed mixed-cell conversion, but at the expense of decreasing the available fish culture volume.

Obstacles – The proposed modifications are straightforward. The center concrete wall of the pond needs to be removed, but this is the only major structural modification. Modifications to the existing supply and drain lines are required, but they do not require excavation.

Cost Opinion – The projected total cost for cost for the renovation of a Burrows pond into a mixed-cell rearing unit is $19,000. This cost assumed a contractor will be hired to complete the renovation and hatchery maintenance staff will supervise construction. The renovation cost is expected to decrease to approximately $9,000 per pond if the hatchery maintenance staff completes the modifications and a contractor is not required.

Item	**Quantity**	**Unit Cost**	**Cost[1]**
Removals	1	Lump Sum	$5,000
Process Piping and Valves	1	Lump Sum	$5,000
Plumbing Installation	40%	$5,000	$2,000
Miscellaneous Labor	1	Lump Sum	$2,000
Subtotal			$14,000
Construction Administration[2]	0%	--	--
Contractor Overhead/Profit	20%	$14,000	$3,000
Contingency	10%	$14,000	$2,000
		TOTAL	**$19,000**

[1]All costs rounded up to the nearest $1,000
[2]Assumes hatchery maintenance staff oversees construction

3. Installation of a Heat Exchanger System to Achieve a Natural Rearing Water Temperature Regime and Energy Savings

Description

Water pumped from the North Fork of the Clearwater River serves as the main water supply for Dworshak NFH, with all of the Burrows ponds, raceways, and holding ponds receiving river water. The North Fork near the hatchery does not follow the natural temperature profile of rivers in the area because it is influenced by the Dworshak Dam, which is over 700 feet high. Water in the North Fork below the dam is influenced by the amount of water the USACE discharges from the dam and by the Dworshak Reservoir, which is approximately 19,800 acres in size at full pool elevation. The Clearwater River, which is located on the south bank of the peninsula where the hatchery is located, is a free-flowing river that follows the expected natural water temperature profile for the area. The maximum water temperature in the North Fork during the month of July is only 47°F on average, compared with the average maximum temperature in the Clearwater River of 77°F. Five-year average temperature profiles of both rivers are presented in Figure 39.

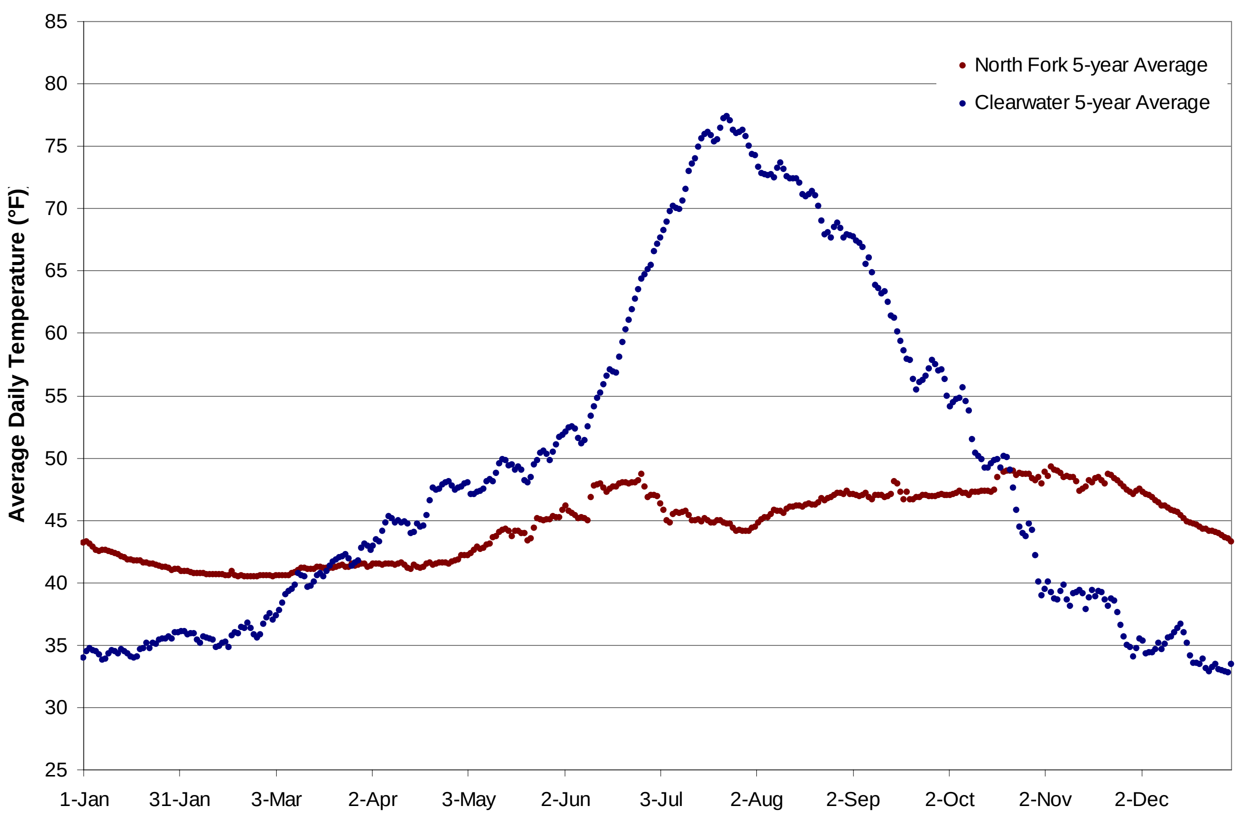


Figure 39. Average water temperature in the Clearwater and North Fork Rivers (North Fork data collected below the Dworshak Dam and Clearwater data collected at a USGS gauging station in Orofino).

The majority of steelhead raised in water directly from the North Fork River do not experience enough growth during the summer and early fall months to reach the target stocking size in April because the colder water of the North Fork suppresses growth. As a result, fish culture water is currently heated to 52°F during the winter months for steelhead production in the Burrows ponds. This increased water temperature accelerates fish growth rates in order to produce one-year-old smolts for April stocking. The Burrows ponds are operated in water reuse configuration when fish culture water is heated in order to conserve energy. Steelhead from the first spawning events do not typically need heated water in the outside ponds because they can achieve the desired growth over the longer growth period; whereas fish from later spawning events require heated water in order to grow to the target stocking size because they have shorter growth periods. As such, only two reuse systems are typically operated with heated water during the winter months.

Makeup water for each reuse system, approximately 10% of the total system flow, is heated using the electric boiler and heat exchanger system in Mechanical Building 2. The heating system is energy intensive, increasing the hatchery's energy use by approximately 2,000,000 kWh per month when in use to heat makeup water for two Burrows pond reuse systems. In addition to the significant energy demand of the heating system, fish experience health problems during operation of the reuse systems, and the heated water operation during the winter does not provide a natural fish growth cycle. As previously indicated in the first recommendation, the current reuse systems do not include effective solids removal processes, which results in poor water quality and numerous fish health problems. Hatchery staff would like to heat water and operate the reuse systems from December through March to increase steelhead growth; however fish health declines and the systems are usually turned off in February. Heating and reuse system operation would not be required if a natural surface water temperature profile could be utilized for steelhead production in Burrows ponds.

RECOMMENDATION

Utilization of a large-scale heat exchanger (HEX) system should be considered to temper hatchery source water from the North Fork River using warmer water from the Clearwater River to create a more natural rearing temperature profile for steelhead in the Burrows ponds. HEX systems have been successfully utilized to increase growth and provide a more natural rearing water temperature profile for fish at several hatcheries. White River NFH (Bethel, VT) utilizes spiral HEX units and surface water from the adjacent White River to increase the temperature of well water for its Atlantic salmon restoration program. Although not currently operated, Fort Richardson SFH (Anchorage, Alaska) effectively operated plate and frame HEX units to warm well water using waste heat from a nearby steam power plant.

Figure 40. One of two plate and frame HEX units at Fort Richardson SFH (Alaska). Both were used to increase the temperature of the influent hatchery water supply.

Utilization of a HEX system at Dowrshak NFH during the summer and early fall months will result in increased fish growth during this time over that which is currently attained when ambient water from the North Fork is used. This increased growth should offset the need to heat water and utilize reuse systems during the winter to speed up growth, resulting in significant energy savings for the hatchery and a more natural rearing profile for fish. As indicated in Figure 39, the Clearwater River has a much higher average water temperature during the period from mid-June through September compared with the North Fork. In addition to the proposed HEX system, an intake structure and pump house should be constructed on the Clearwater River to collect water from the river and pump it through the heat exchanger system and back to discharge downstream of the new pump house. A process flow diagram of the proposed HEX system is provided in Figure 41.

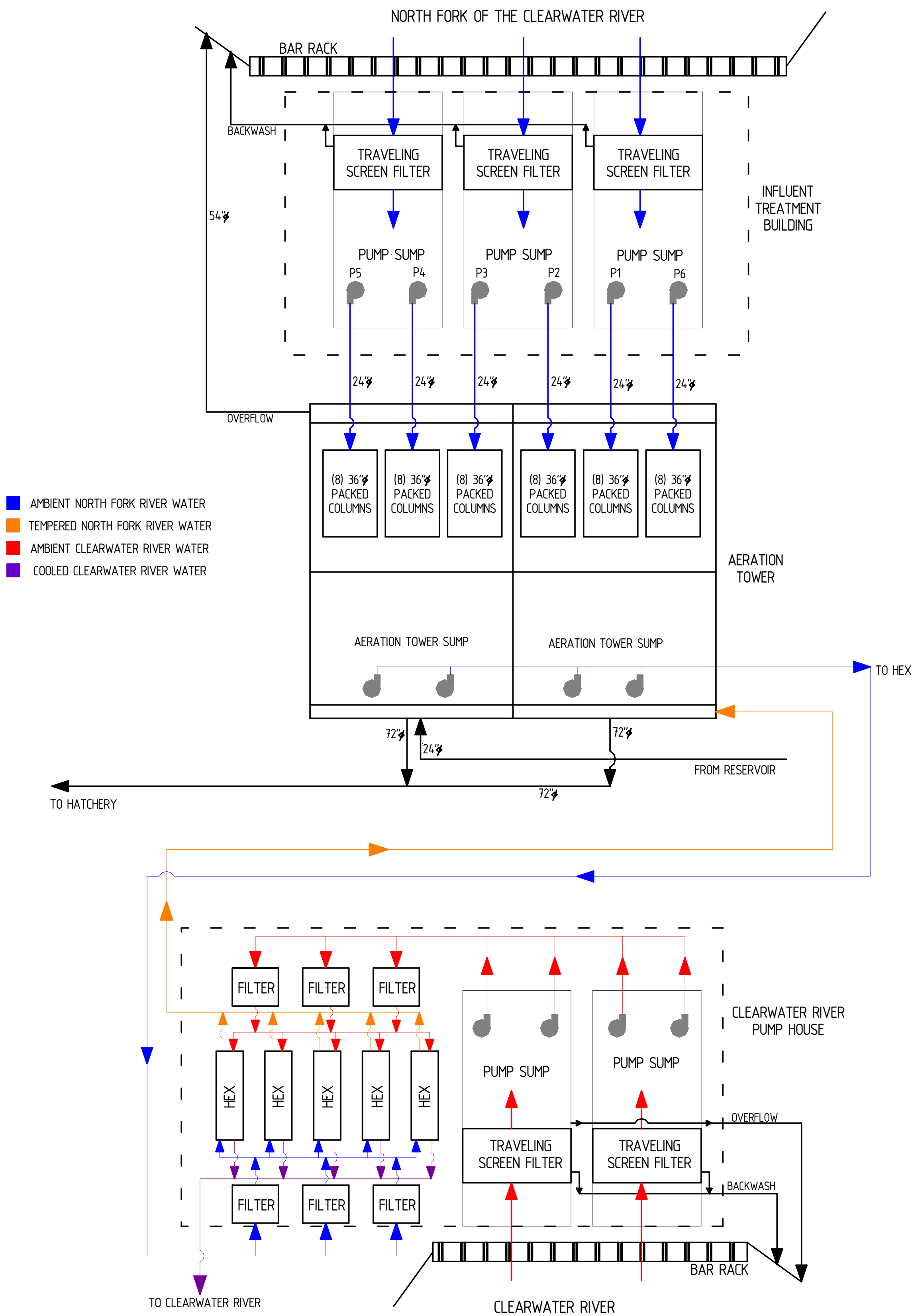


Figure 41. Proposed HEX system process flow diagram.

FEASIBILITY

The construction of a new river intake structure and pump house is feasible on the bank of the Clearwater River. The new Clearwater River pump house should be similar to the existing pump house on the North Fork, with a scaled-down version of the existing intake bar rack, traveling screen filter, and pumping systems used to collect and pump water from the North Fork. The new pump house building should also include space to house the proposed HEX system. Although the equipment will be smaller, the building should be approximately the same size to accommodate the new HEX and filtration system. New process piping is required to pump Clearwater River water through the HEX units and discharge it back to the river. The proposed location of the new pump house on the Clearwater River is indicated on the modified facility layout included in the Appendix.

Current process piping does not allow for isolation of the North Fork River water supplied to the Burrows ponds from the river water supply for the rest of the hatchery. In order to minimize process piping modifications, it is recommended that a central HEX system be installed that will temper water for all outdoor fish culture activities during the applicable time period and not just for the Burrows ponds. The resulting treated water temperature profile will be more natural and beneficial for all fish in the outdoor rearing areas. New pumps can be installed in the main aeration tower sump to pump North Fork River water through the proposed HEX system and back to the aeration tower sump. Pumps should be installed in the aeration tower sump near the existing concrete outlet weir on the upstream side. Tempered North Fork water from the HEX units should be discharged into the aeration tower sump on the opposite side of the outlet weir and then gravity-flow to the hatchery via the existing 72-inch diameter main supply line. Each side of the aeration tower sump has its own concrete outlet weir, which are different heights. The top elevation of the outlet weir on the west side of the sump is 1,005 feet and the elevation of the weir on the east side is 1,001 feet. The height of the lower weir should be increased to 1,005 feet when the proposed pumps are installed so that the weir heights are identical. The installation of new process piping is also required for pumped water from the aeration tower through the HEX system and back to the aeration tower sump.

The installation of plate and frame HEX units is recommended over spiral or tube and shell units. Plate and Frame HEX units are more cost effective and have a smaller footprint for the application. The proposed plate and frame HEX system consists of five plate and frame units, which will allow for staged operation and provide system flexibility. Each unit should be stainless steel and have a total heat transfer surface area of 13,842 ft^2. Each unit was sized to temper 8,500 gpm of water from the North Fork to a temperature of 52.5°F starting in mid-June when the temperature of the Clearwater River is approximately 54°F and the temperature of the North Fork is approximately 47.5°F. Steelhead and Chinook are just beginning to be stocked into outdoor Burrows ponds and raceways in June, and the water demand for outdoor fish culture using the North Fork is approximately 25,000 gpm. This demand will require the use of three of the five proposed HEX units. In June, 8,500 gpm of North Fork water from the main aeration tower will be pumped through the cold side of each of the three operating HEX units and 8,500 gpm of warm water from the Clearwater River will be pumped through the hot side of each HEX. This operational scenario will warm the full 25,500 gpm North Fork flow to 52.5°F for use in outdoor fish culture.

As more fish are stocked into outdoor rearing areas, the amount of water used from the North Fork River increases, during which time the temperature of the Clearwater River also increases. As the water use on station rises, the quantity of HEX units put into service should increase until all five HEX units are in use. When all five HEX units are operational, the proposed system has the capacity to temper a maximum of 42,500 gpm of water from the North Fork. This flowrate is below the 77,400 gpm anticipated maximum flowrate required from the North Fork during summer operation of the proposed heat exchanger system when the raceways and Burrows ponds are full. Operation of the proposed HEX system will remain the same during this time, with North Fork water being pumped from the man aeration tower sump through the HEX system and back to the aeration tower sump, but the HEX system will become a side-stream treatment process, tempering only part of the hatchery river water supply. As the water temperature in the Clearwater River rises above the mid-June temperature of 54°F, the tempered water from the North Fork will increase above the 52.5°F target temperature. For instance, when the Clearwater River reaches its average maximum summer temperature of 77°F, the tempered North Fork water from the HEX system is expected to be 71°F. The 42,500 gpm of tempered North Fork water at 71°F would be mix with the 45°F temperature of the ambient North Fork water in the aeration tower sump just before exiting.

The inclusion of additional filtration equipment on the influent side of the HEX system should be considered to remove finer solids from the North Fork and Clearwater Rivers and minimize fouling and maintenance within the HEX system. The existing traveling screen filters in the North Fork River pump house have 3/8-inch square mesh openings, which will not exclude finer solids that may plug the HEX units. The screens on the existing filters could be replaced with smaller mesh openings, but this will result in frequent backwashing of the units. Standard filtration equipment is available for installation in conjunction with plate and frame HEX units. The recommended filters are a type of a pressure filter with removable filter basket and automatic flushing systems. Filter baskets with wedge wire screen openings less than ¼-inch are recommended. Three filters should be installed to treat North Fork water from the aeration tower and three filters should be installed to treat water from the new Clearwater River pump sump prior to HEX units. Each filter should treat 14,167 gpm.

The operation of the proposed HEX system during the summer months will eliminate the need to operate the energy-intensive boiler system to heat makeup water and to operate the reuse systems for Burrows ponds during the winter, but the HEX system also has operational costs. However, the projected energy requirement and pumping costs associated with the HEX system are less than the energy required to operate the boiler and reuse systems. A 25% energy savings per year is anticipated with implementation of the proposed HEX system. A summary of equipment used in the energy analysis is provided in Table 9. A relative comparison of the estimated energy required to operate this equipment is summarized monthly in Table 10. With the implementation of a HEX system the operation of the reuse systems could be abandoned, saving approximately 12 million kWh each year. This power would then be available for the local power company to sell to residential, commercial, and industrial consumers in the area. At a residential service rate of $0.07/kWh, the power company would generate an extra $823,000 in revenue per year and would generate $470,000 per year at the industrial service rate of $0.04/kWh.

	Equipment Used in Energy Balance Under Current Operation	**Equipment Used in Energy Balance Under HEX System Operation**
January	▪ Systems I & II in reuse the entire month ▪ 4 pumps in main pump house	▪ 6 pumps in main pump house
February	▪ Systems I & II in reuse for 20 days ▪ 4 pumps in main pump house for 20 days ▪ 6 pumps in main pump house for 8 days ▪ Nursery tanks heated the entire month	▪ 6 pumps in main pump house ▪ Nursery tanks heated the entire month
March	▪ 5 pumps in main pump house ▪ Nursery tanks heated the entire month	▪ 5 pumps in main pump house ▪ Nursery tanks heated the entire month
April	▪ 5 pumps in main pump house ▪ Nursery tanks heated the entire month	▪ 5 pumps in main pump house ▪ Nursery tanks heated the entire month
May	▪ 2 pumps in main pump house ▪ Nursery tanks heated the entire month	▪ 2 pumps in main pump house ▪ Nursery tanks heated the entire month
June	▪ 2 pumps in main pump house ▪ Nursery tanks heated for 15 days	▪ 2 pumps in main pump house ▪ Nursery tanks heated for 15 days ▪ HEX system pumps
July	▪ 4 pumps in main pump house	▪ 4 pumps in main pump house ▪ HEX system pumps
August	▪ 5 pumps in main pump house	▪ 5 pumps in main pump house ▪ HEX system pumps
September	▪ 6 pumps in main pump house	▪ 6 pumps in main pump house ▪ HEX system pumps
October	▪ 6 pumps in main pump house	▪ 6 pumps in main pump house
November	▪ 6 pumps in main pump house	▪ 6 pumps in main pump house
December	▪ Systems I & II in reuse for 15 days ▪ 4 pumps in main pump house for 15 days ▪ 6 pumps in main pump house for 15 days	▪ 6 pumps in main pump house

Table 9. Summary of equipment used in HEX system energy savings analysis.

	Estimated Current Energy Use (kWh/month)	**Estimated Energy Use with HEX System (kWh/month)**
January	7,704,450	1,338,412
February	7,557,361	2,952,562
March	7,055,870	6,587,425
April	7,994,595	7,526,151
May	4,577,900	4,109,456
June	2,481,991	2,816,526
July	892,275	1,840,202
August	1,115,343	2,063,270
September	1,338,412	2,286,339
October	1,338,412	1,338,412
November	1,338,412	1,338,412
December	4,351,838	1,338,412
TOTAL	47,746,859	35,535,578

Table 10. Monthly summary of estimated current and future energy use with HEX system.

Benefits – Implementation of the HEX system will result in significant yearly energy savings at the hatchery. The boiler systems in Mechanical Building 2 will not be required to heat fish culture water for use in the Burrows ponds during the winter since the water from the HEX system will be warmer during the summer months; the steelhead will grow more naturally during this period. The energy consumed during operation of the HEX system is associated with pumping water from the Clearwater River through the HEX system and also pumping North Fork River water from the main aeration tower sump through the HEX system. In addition to energy savings, steelhead will be reared in a more natural water temperature profile and experience a natural growth cycle having increased growth during warmer months and less growth during winter months.

Obstacles – The construction of a new building with an intake structure and pumping capabilities is required on the Clearwater River to collect and pump warm water through the HEX units. New process piping is required from the main aeration tower sump to the proposed new building on the bank of the Clearwater River, and additional process piping is required within the building. Three or four pumps are required to pump water from the main aeration tower through the HEX system; minor modifications to the main aeration tower and pump support structures are required. There do not appear to be any significant legal obstacles to utilizing water from the Clearwater River in a HEX system; the water will be discharged back into that river, and will not come into direct contact with fish. The Clearwater River water discharged from the HEX system will be slightly cooler, but it will mix with the full river flow upon discharge and is not expected to significantly impact the river environment. The hatchery will likely be required to obtain a water use permit and other permits for construction activities in the Clearwater River.

Cost Opinion –

Item	**Quantity**	**Unit Cost**	**Cost**[1]
Plate and Frame Heat Exchangers	5	$165,000	$825,000
Pressure Filter Strainers	6	$137,500	$825,000
Clearwater River Intake Bar Rack	1	Lump Sum	$30,000
Clearwater River Traveling Screen Filters	2	$150,000	$300,000
HEX and Pump House Building[2]	1	Lump Sum	$2,000,000
Clearwater River Pumps	4	$105,000	$420,000
Aeration Tower Pumps	4	$105,000	$420,000
Aeration Tower Modifications to Support Pumps[3]	1	Lump Sum	$50,000
Process Piping and Valves[4]	1	Lump Sum	$1,200,000
Subtotal			$6,070,000
Design	10%	$6,070,000	$607,000
Construction Administration	5%	$6,070,000	$304,000
Contractor Overhead/Profit	20%	$6,070,000	$1,214,000
Contingency	10%	$6,070,000	$607,000
		TOTAL	**$8,802,000**

[1]All costs rounded up to the nearest $1,000
[2]Includes building utilities
[3]Includes utilities
[4]Process piping estimated at $200/ft^2 including installation, excavation, and backfill

4. Improved Dissolved Gas Conditioning of the Nursery Room Water Supply

Description

Indoor nursery tanks are used for steelhead fry from January through August each year. Water from the Dworshak Reservoir is always used to supply the nursery tanks. Reservoir water is heated from January through May until the ambient reservoir water temperature rises above 54°F. Process piping to the nursery building allows the direct use of ambient reservoir water in any of the tanks. Heated reservoir water directly from Mechanical Building 1 can be used in the A bank of tanks, but is not typically used in the nursery tanks due to insufficient system heating capacity. Heated reservoir water from Mechanical Building 2 is typically used in the nursery building. Process piping does not allow heated water from Mechanical Building 2 to flow directly to the nursery building; it is directed to the outdoor nursery head tanks and then flows by gravity to the nursery building. The typical water supply to each nursery tank is 40 gpm, and the total water use in the nursery room is 5,120 gpm when all 128 tanks are in use.

Reservoir water is currently treated with individual packed columns above each nursery tank. Packed columns have higher than recommended hydraulic loading rates, and dissolved gas measurements in nursery tanks indicate elevated levels of dissolved nitrogen saturation (Table 2). Average fall 2007 measurements indicated ambient reservoir water after treatment with a nursery tank packed column remained super-saturated with dissolved nitrogen at 103%. Heated reservoir water (54°F) prior to treatment with the nursery tank packed column had a dissolved nitrogen content of 113% of saturation, which was reduced to 104% after treatment with the nursery tank packed column. Dissolved nitrogen gas saturation over 102–104% is a chronic stress to juvenile fish. Current water quality is not optimal and should be addressed by improved dissolved gas conditioning.

Recommendation

A centralized dissolved gas conditioning system should be implemented to replace the 128 individual packed columns that are currently above each nursery tank. Conversion of the existing outdoor nursery head tanks to accommodate a central dissolved gas treatment system was considered, but would require significant modifications to the towers. Modifications could not be accomplished to provide an effective dissolved gas treatment system while maintaining the gravity-flow nature of the heated water supply to the nursery building due to the existing grade elevations. Modifying the head tanks into a centralized treatment system would also involve process piping modifications to direct the reservoir supply line to the towers. Ambient reservoir water currently goes directly to the nursery building, but also requires centralized dissolved gas conditioning treatment. Locating the treatment system with the outdoor nursery head tanks would increase the heating demand on the mechanical building; process water will require additional heat input to account for the heat lost as the treatment system is exposed to the elements.

Two process treatment options should be considered to treat dissolved gases in the water supply for the nursery building. The first process treatment option entails the use of an open packed column coupled with a low head oxygenator (LHO) underneath. The second option is a variation of the first and includes the use of a vacuum-degassing column followed with an LHO. Processes in both options are stacked on top of one another, and stacks are similar in terms of the dimensions of equipment that are recommended. Dissolved gas treatment equipment stacks can be custom-fabricated, or are available as standard off-the-shelf equipment (Figure 42).

Figure 42. PR Aqua, Ltd. OxyTower™ dissolved gas conditioning equipment that treats 1,000 gpm.

FEASIBILITY

The use of four separate dissolved gas conditioning systems should be implemented to treat water that is used in the nursery building; one system per bank of 32 tanks. The systems should be located within a newly constructed addition to the nursery building adjacent to the wall where the existing water supply lines enter the building. The proposed location of the addition is indicated on the modified facility layout included in the Appendix. Enclosing the equipment within a structure is recommended to reduce heat loss from the process water following its heating in the mechanical building. A roof eave height of approximately 25 feet is required in the area where the proposed equipment will be installed, which is considerably higher than the current roof height of the nursery building. The proposed system elevations are recommended to allow for treated water to gravity-flow to the nursery tanks. An elevation sketch of the proposed dissolved gas conditioning stack system is provided in Figure 43.

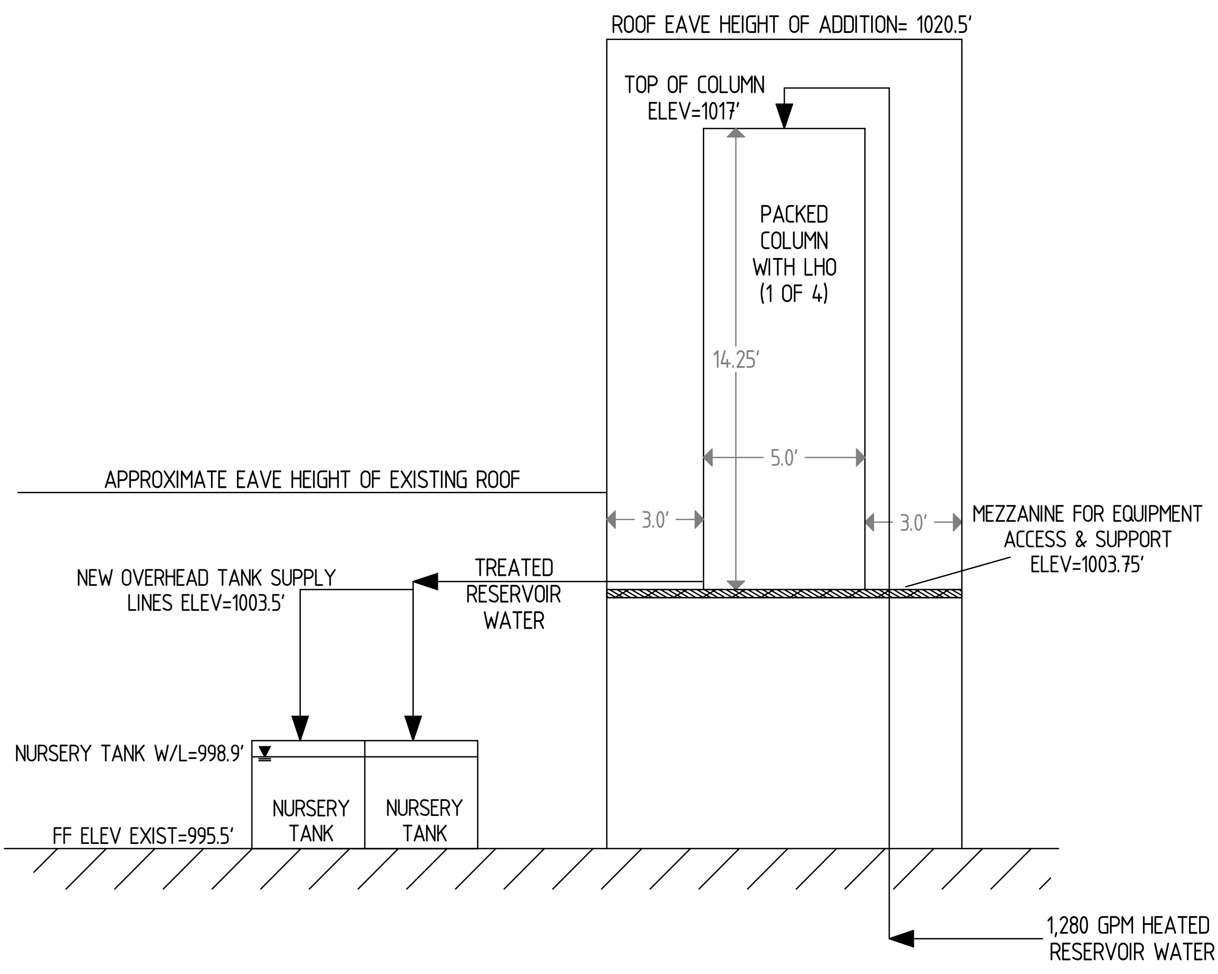


Figure 43. Elevation sketch of proposed dissolved gas conditioning system for nursery building.

In operation, 1,280 gpm of reservoir water enters the top of each packed column/LHO stack, and carbon dioxide and nitrogen are removed from the water supply as it flows through the column and is broken up by packing in the top portion of the column. The column should have a minimum packing depth of four feet, and a distribution plate should be installed above the packing to evenly distribute water over the entire cross sectional area of the column below the plate. Each stack should be five feet in diameter, providing a hydraulic loading rate of 65 gpm/ft^2 for the design flowrate of 1,280 gpm. An LHO should be located below the stripping column; pure oxygen will be added to the LHO to increase the dissolved oxygen content of the well water and further decrease the dissolved nitrogen concentration. Each packed column/LHO stack should be positioned within a sump with the bottom of the LHO submerged. The sump should have an operational water depth maintained at an elevation to provide enough head pressure to feed its respective bank of nursery tanks. The LHO sump should have a cone-shaped bottom with cleanout.

Since water is heated before use in the nursery tank building five months each year, the use of non-force-ventilated packed columns operated at atmospheric pressure is recommended to avoid the additional heat loss that would be incurred with blowing non-heated air through the packed columns. Even if the columns are not force-ventilated, some of the heat added to reservoir water in the mechanical buildings will be lost within the packed column as water disperses over packing within the columns, which are open to the atmosphere. To decrease the amount of heat lost from the system, the packed columns can be converted to vacuum-degassing columns with minor modifications. Modifications include closing the top of the packed columns and adding small ports/chimneys to allow for the creation of an operational vacuum and outlet for off-gases.

In operation, a vacuum pump or regenerative blower could be used to create a vacuum within each column. Water enters the top of each closed column and dissolved nitrogen, carbon dioxide, and oxygen are removed from the process water as gases exit the column to the atmosphere, which is at a lower pressure. The presence of packing media within the column breaks up the water flow, increasing the surface area for liquid to gas transfer. The creation of a vacuum reduces dissolved gas levels below saturation, including oxygen; whereas oxygen is passively added to process water in an open packed column system. The use of an LHO with pure oxygen is recommended following both the open packed column and vacuum-degassing column, but the vacuum-degassing column will require more pure oxygen to be added to process water. In addition to increased oxygen use in the vacuum-degassing columns, the pumps and operational control systems required for each vacuum-degassing column increases system maintenance.

The precise amount of heat lost or maintained with both options has not been determined; however, all proposed equipment should be located indoors to reduce heat loss from the system. It is also recommended that process piping be maintained below-grade and located indoors to the extent possible to further reduce heat loss. Implementation of the proposed dissolved gas conditioning systems require piping modifications to tanks within the nursery building, which is scheduled as part of the building roof replacement in the fall of 2008. Outdoor piping modifications are also required to implement the proposed systems.

When reservoir water is heated for use in the nursery building, it is directed to the outdoor nursery head tanks and then gravity-flows to the nursery building. Heated reservoir water from Mechanical Building 1 can be transferred to the nursery building directly (currently to the A Bank of nursery tanks), but Mechanical Building 1 is not typically used to heat water for the nursery building because it lacks the operational capacity to do so. Heated reservoir water from Mechanical Building 2 is typically used in the nursery building; however, it can not be sent to the nursery building directly and must first go to the outdoor head tanks. The head tanks have an above-grade operational water level of 20.67 feet, providing a constant water pressure of approximately 16 feet to the nursery tanks. The head pressure provided by the operational water level in the outdoor nursery tanks is insufficient for operation of the dissolved gas treatment systems as proposed without additional pumping. Approximately 12–18 inches of freeboard is reportedly available within the nursery head tanks above the current operational tank water level, but it is not enough to make the system work if the operational water level was raised. Additional pumping would be required following the outdoor nursery head tanks if they are used.

It is recommended that the outdoor nursery head tanks be abandoned and process piping be modified to direct the heated reservoir line from Mechanical Building 2 to the proposed treatment equipment adjacent to the nursery building. The Mechanical Building 2 system has the capacity to accommodate pumping the water to the new treatment equipment after the installation of new process piping. Available water pressure head from the reservoir is sufficient for operation of the proposed treatment equipment when ambient reservoir water is used. Ambient reservoir water currently enters the nursery building through one of four supply lines, which could be easily re-directed to the dissolved gas treatment equipment in the proposed locations. Each of the proposed packed column/LHO stacks includes a sump that will provide a constant water pressure supply for the nursery tanks, while maintaining the overhead piping to tanks within the building. The overhead piping is required to maintain access throughout the building.

Benefits – The installation of the proposed dissolved gas conditioning stacks will result in better quality water being supplied to fry in the nursery tanks. Dissolved nitrogen saturation in the water currently supplied to the nursery tanks remains higher than recommended after treatment with the packed columns that are currently used above the tanks. Reducing the dissolved nitrogen super-saturation in fish culture water used to raise fry will result in less stress on the early life stages. This reduction in stress will improve overall fish health. The installation of one packed column/LHO stack per bank of nursery tanks will reduce the labor that is required versus maintaining the 128 packed columns currently used in the nursery building. Using one stack per bank of tanks allows for operational flexibility as fish are being stocked into and out of the nursery tanks. The upcoming replacement of the nursery building roof, scheduled for the fall of 2008, presents a reasonable opportunity for upgrading the dissolved gas treatment of the water supply to the nursery building.

Obstacles – No major obstacles to the installation of the proposed four dissolved gas conditioning stacks are foreseen. Significant process piping modifications are required. Existing water supply piping within the nursery building will most likely be replaced with the replacement of the building roof in the fall of 2008. Outdoor piping modifications are required to connect the heated water line from Mechanical Building 2 to the new treatment equipment at the proposed location adjacent to the nursery building. The required roof height for the area where the dissolved gas conditioning treatment equipment will be located is approximately 25 feet, which is higher than the current nursery building roof. Since there is not enough room in the nursery building to install the proposed equipment, a small addition should be constructed adjacent to the building to house the equipment. The proposed location of the addition is indicated on the modified facility layout included in the Appendix.

Cost Opinion –

Item	**Quantity**	**Unit Cost**	**Cost**[1]
Nursery Building Addition[2]	750 ft^2	$325/$ft^2$	$244,000
OxyTower™ 1000 with Sump	4	$25,000	$100,000
Process Piping and Valves[3]	1	Lump Sum	$140,000
Miscellaneous Labor and Installation	1	Lump Sum	$25,000
Subtotal			$509,000
Design	10%	$509,000	$51,000
Construction Administration	5%	$509,000	$26,000
Contractor Overhead/Profit	20%	$509,000	$102,000
Contingency	10%	$509,000	$51,000
		TOTAL	**$739,000**

[1]All costs rounded up to the nearest $1,000
[2]Includes building utilities
[3]Civil yard piping, estimated at $200/$ft^2$ including installation, excavation, and backfill

Maintenance Needs

The following facility maintenance needs related to fish production, water infrastructure, and hatchery buildings have been identified at Dworshak NFH.

1. Modifications to hatchery effluent to comply with new NPDES standards.
2. Repairs to valves supply water to each Burrows pond. Several of the ponds have low flows because the valves are plugged. Repairs require each valve to be dug up and dismantled when the respective system is not in operation.
3. Install heat exchangers to replace boilers.
4. Fix leaking concrete Burrows ponds or retrofit with circular tanks.
5. Fix leaking concrete tanks in nursery or retrofit with new tanks.
6. Modify existing reuse systems so they are more efficient and functional.
7. Increase generator capacity to provide more backup power in case of power outage.

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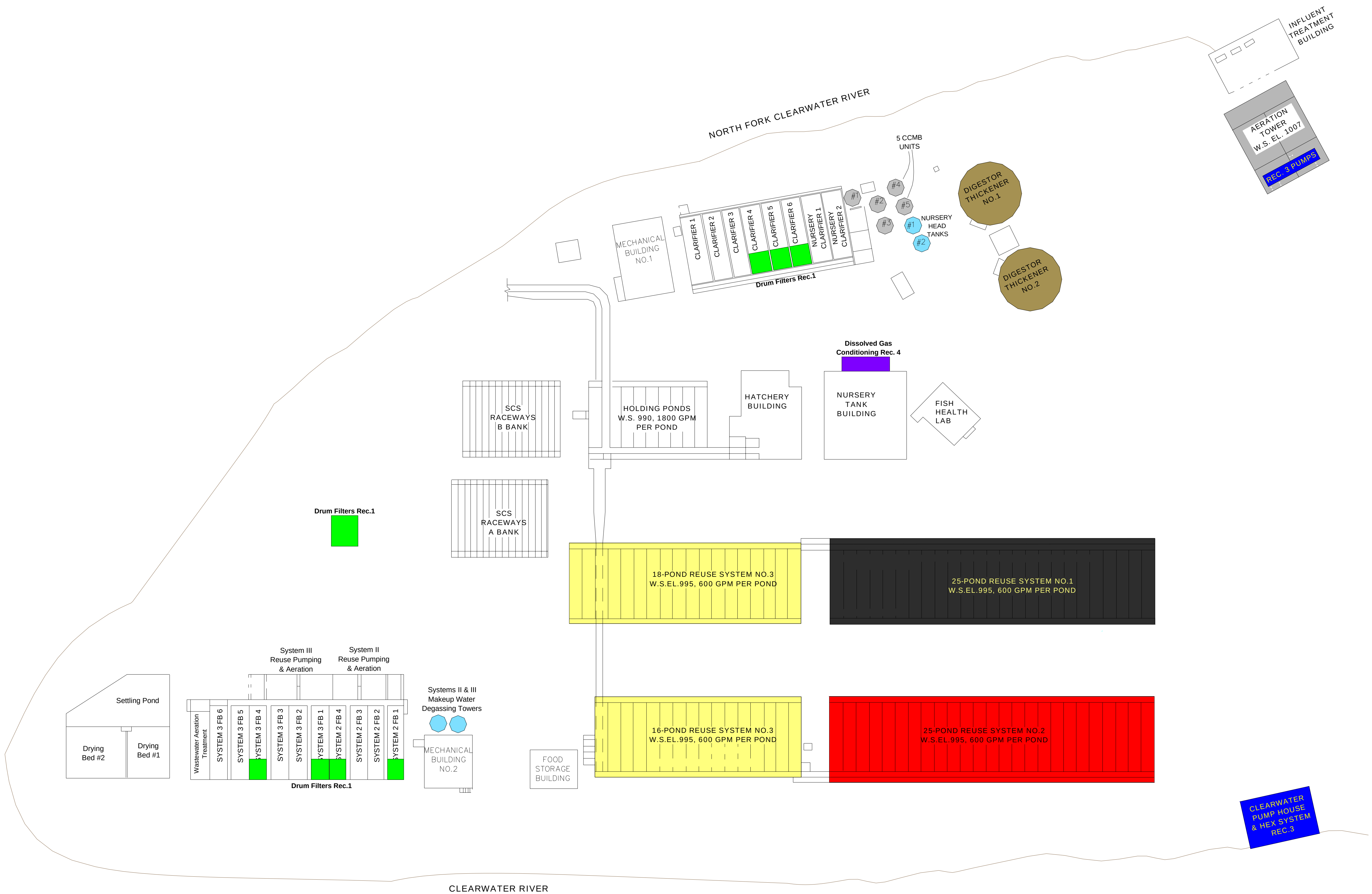
APPENDIX



Layout of Dworshak NFH with the locations of recommended facility improvements identified.

System II for February Reuse Operation - with Dec. 07 bioplan information from edited report

Inputs				**Reference/Comments**
Bio Plan				
Number of Ponds	25			
Pond Width	17.1	ft		Pond Rearing Volume
Pond Length	75			3,206ft^3
Pond Water Depth	2.5	ft		23,986 gal
Feb Density	20.4	kg/m3		
Size in feb	61.9	g		Stocking goal for April is 5-6 FPP, 180-200 mm
Number of Fish in System	750,000	fish		30,000 fish per pond
Feb Biomass in system II	46,396	kg		
Maximum Feed Rate	0.00836	BW/day	854	lb feed/day (855 lb/day Feb. feed fed from new bioplan table)
Dissolved Oxygen				**DO Saturation: f(T,Elev)**
Max Water Temp	11.1	degC	10.6	52° water temps during reuse
Elevation above Sea Level	314	m		1030 ft
Inlet DO	10.60	mg/L		with LOX
Outlet DO	**5.7**	**mg/L**		> 6 mg/L or 90 mmHg
DO Consumption Rate	0.46	kg DO/kg feed		Summerfelt et al., 2004: *Salmo* data only
Ammonia Nitrogen				
pH	6.89			
Alkalinity	20	mg/L		Estimate based on measured reservoir water
Culture Tank TAN Level	**2.62**	**mg/L**		
Culture Tank UIA Level	**0.0055**	**mg/L**		Adjust (pH or TAN) to get UIA close to 0.0125
Feed Protein Level	50	%		From BioVITA feed specifications (1.5 mm feed and larger)
TAN Production Rate	0.046	kg TAN/kg feed		f(%protein): Timmons et al., 2001
Carbon Dioxide				
Culture Tank CO2 Level	**15.00**	**mg/L**		Max level of 15 to 20 mg/L
CO2 Production Rate	0.63	kg CO2/kg feed		Timmons et al., 2001
Solids				
TSS Production Rate	0.35	kg TSS/kg feed		Timmons et al., 2001
Tank Diameter to Depth Ratio	6.8	ft/ft		4–6 is the target; Timmons et al., 2001
Tank Rotational Period at 1 BL/sec wall velocity	54	seconds		60–96 seconds; Davidson & Summerfelt, 2004
Tank Exchange for Self Cleaning	**45**	**minutes**		
Makeup Water				
Make-up Flow Rate	**1250**	**gpm**		
Make-up Water DO Concentration	10.6	mg/L		95% saturation value
Make-up Water TAN Concentration	0.03	mg/L		Well water measured 2005
Make-up Water CO2 Concentration	1.5	mg/L		Well water measured 2005
Make-up Water TSS Concentration	0.5	mg/L		
Treatment Efficiency				
CO2 Removal Efficiency	0.55	ratio		Packed column with variable speed fan to control pH
TAN Removal Efficiency	0.00	ratio		Assumes No Biofiltration
TSS Removal Efficiency	0.90	ratio		Cornell Dual Drain/MS Filter
O2 transfer efficiency (worst case)	65	% transferred		Not used
Daily ozone application rate	0.02	kg O3/kg feed		Not used

REQUIRED FLOWS

Reuse Flow Required based on DO	5,446	gpm	UIA = 0.0125 mg/L at 2.62 mg/L TAN and pH of 7.24
Total Flow Required based on DO	**6,696**	**gpm**	UIA = 0.0112 mg/L at 2.62 mg/L TAN and pH = 7.2 (0.5*CO2 level)
Reuse Flow Required based on TAN	NA	gpm	UIA = 0.0125 mg/L at pH = 6.89 and 5.98 mg/L TAN
Total Flow Required based on TAN	**NA**	**gpm**	
Reuse Flow Required based on CO2	3,525	gpm	
Total Flow Required based on CO2	**4,775**	**gpm**	
Total Flow Required based on TEX	**2,386**	**gpm**	

DESIGN

Design Total Flow	**12,500**	**gpm**	
Return Flow per pond	**500**	**gpm**	
Reuse Flow per Pond	**450**	**gpm**	
Makeup Flow per Pond	**50**		
Flow Reuse Fraction, R	**0.90**		Summerfelt et al., 2001
Culture Tank DO Concentration	**5.7**	**mg/L**	Previously defined
Culture Tank TAN Concentration	**2.62**	**mg/L**	
Culture Tank UIA Concentration	**0.0055**	**mg/L**	< 0.0125 mg/L is max safe level
Culture Tank CO2 Concentration	**6.20**	**mg/L**	< 20 mg/L is safe
Culture Tank TSS Concentration	**2.24**	**mg/L**	
Ratio UIA:TAN	**0.0021**		
Tank Exchange Rate	**48**	**minutes**	
Flow through TAN at Design Total Flow	**0.29**	**mg/L**	Summerfelt & Vinci, 2004
Flow through CO2 at Design Total Flow	**5.10**	**mg/L**	Summerfelt & Vinci, 2004
Flow through Delta DO at Design Total Flow	**2.62**	**mg/L**	Summerfelt & Vinci, 2004